Research Note 82-22

AD A127...

DEVELOPMENT AND EVALUATION OF A GENERALIZABLE JOB PROFICIENCY MATRIX

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U. S. Army

Research Institute for the Behavioral and Social Sciences

MAY 1980

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83 04 21 123

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Research Note 82-22	2. GOVT ACCESSION NO. AD-A127 077	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Development and Evaluation of a Generalizable Job Proficiency Matrix		5. TYPE OF REPORT & PERIOD COVERED 9/27/77 - 5/26/80
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Terrance G. Hanson, Alfred N. Behm, Daniel C. Johnson, Stephen F. Hirshfeld, and Richard E. Vestewig (Honeywell, Inc.)		8. CONTRACT OR GRANT NUMBER(s) DAHC 19-77-C-0026
9. PERFORMING ORGANIZATION NAME AND ADDRESS Personnel Decisions Research Institute 821 Marquette Avenue Minneapolis, MN 55402		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q763731A770
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Research Institute for the Behavioral and Social Sciences. 5001 Eisenhower Avenue, Alexandria, Virginia 22333		12. REPORT DATE May 1980
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Prepared under subcontract by Honeywell, Inc., Systems & Research Center, 2600 Ridgway Parkway, Minneapolis, MN 55413

Contracting Office's Technical Representatives-Milton Maier & Douglas Ramsey(ARI)

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Performance Taxonomies
Ability Taxonomies
Skill Qualification Tests
Electronic Troubleshooting
Avionics
Maintenance

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This project explored the feasibility of constructing task-by-element matrices for three avionics MOSs--35L, 35M, and 35R. Matrix rows define critical tasks, and columns specify behavioral elements (soldier perceptions, decisions, and actions) required for succesful task performance. The GJPM identifies commonalities among tasks within and across MOSs based on behavioral content. Concurrent with this analysis, a generalizable avionics troubleshooting guide was developed. The GJPM was used to develop prioritized task lists,

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Unclassified

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identify performance measures for critical tasks, and identify behavioral elements common across tasks in one or more MOSs. SQT written components were developed for the three MOSs. The GJPM facilitated MOS content coverage while reducing unecessary redundancy.

Interviews were conducted upon completion of the SQTs to evaluate the usefulness of the GJPM for SQT development, training design, training media evaluation, and MOS management, and to discuss appropriate levels of matrix task and element specificity.

The project demonstrated that the GJPM facilitates SQT development. Interviews suggest that the GJPM will be useful for training, training device design, and test design and development. The GJPM is a systematic approach that can point out areas of commonality not previously apparent, and can identify areas of differences where commonality had been assumed.

A

PREFACE

The generalizable job proficiency matrix (GJPM) concept was developed to provide training developers with a formal and systematic method for the analysis of the behavioral and cognitive elements of job performance that is applicable to a wide range of training related areas. GJPMs were developed for three avionics maintenance military occupational specialities (MOS) and applied during the construction of three skill qualification tests (SQT). The favorable evaluation by Army personnel of these SQTs relative to existing SQTs points to the usefulness of the GJPM concept in the development of SQTs suggests the utility of further refinement and application of the concept to other areas of training design, evaluation and MOS management.

We wish to acknowledge the contributions of various organizations to this effort. Honeywell's Systems and Research Center performed this effort as a subcontractor to Personnel Decisions Research Institute (PDRI), and we would like to thank PDRI for their timely delivery of technical documentation. We want to make special mention of the contribution provided by Honeywell's Avionics Technical Training Group. Paul Santori, Kevin Austin, Robert Dawson, and Charles Biakowski prepared the generalized trouble-shooting guide, assisted us in matrix and test development, and provided subject matter expertise during in depth internal reviews. We finally want to express our gratitude to the Signal School. The support we received was outstanding during all stages of the contract; initial data gathering, matrix development, commonality analyses, SQT construction, and the interview phase. We would in particular like to thank Harold Knippenberg, John Rogers, and Sgts. Barce, Jordan, and Riley for their analysis and comments throughout the contract. We believe the GJPM will facilitate the performance of their critical job and result in improved training analyses and products.

DEVELOPMENT OF A GENERALIZABLE JOB PROFICIENCY MATRIX

BRIEF

Requirement:

To develop a new taxonomic system approach, called the generalizable job proficiency matrix (GJPM), to be used in the analysis of three avionics maintenance military occupational specialties (MOS); to apply the GJPM during the development of written components for three avionics maintenance Skill Qualification Tests (SQT); and to develop a generalizable troubleshooting guide for maintaining avionics equipment.

Procedure:

This research effort resulted in the construction of task by element matrices for the tasks in three avionics MOSs--35L, 35M, and 35R. The matrices are characterized by rows defining the critical tasks in each MOS and columns specifying the behavioral elements involved in task performance. These matrices provide users with a systematic method for identifying commonalities among tasks within and across MOSs based on behavioral content. Concurrent with this analysis, a generalizable troubleshooting guide was prepared for the Signal School.

The key ingredients in the GJPM are the behavioral elements (i.e., the perceptions, decisions, and actions) required of the soldier for successful task performance. A behavioral element must be defined sufficiently broadly to allow generalization beyond its immediate application, yet precise enough in its terminology and behavioral descriptions to be interpretable by the training developer. Such a set of elements was developed during the contract.

Draft matrices were reviewed by subject matter experts at the Signal School. Their inputs were used in developing a consistent, economical final set of descriptors.

The matrices were used in developing prioritized task lists, in identifying performance measures within tasks most critical to overall task performance, and in identifying behavioral elements common across tasks in one or more MOSs.

Written components were developed for SQT 2 and SQT 3 in MOSs 35L, 35M, and 35R. SQTs 2 and 3 are the instruments used for skill verification and promotion qualification for enlisted grades E-4 and E-5, respectively. Scorable unit construction followed directly from the earlier tasks. The commonality analyses facilitated the efficient development of items providing adequate MOS coverage while avoiding unnecessary redundancy.

Interviews were conducted at the Signal School upon completion of the SQTs. Discussion centered around the applicability of the GJPM to SQT development, defining training requirements, making training media recommendations, and MOS management. The appropriate level of task specificity required for matrix analysis was also discussed.

Findings:

There were three major findings in this program.

1. The generalizable job proficiency matrix was a significant aid in developing written SQTs that were representative and exhaustive of the tasks necessary for adequate performance within the MOS.

2. The process of constructing the GJPM necessitated judgements for the MOSs on the equipment, actions, and knowledge commonalities and differences that led to greater understanding by the developers and by signal school personnel of the skills and responsibilities of each MOS.

3. The level of the behavioral component specificity of the task analysis in the GJPM was appropriate for SQT development, but should be tailored to a greater or lesser degree of specificity to the objectives associated with its particular application.

Utilization of Findings:

The present contract demonstrated that the GJPM can facilitate the development of improved, more generic SQTs. The GJPM can be applied to other MOSs for further SQT development or for use as a general analysis tool. The use of the GJPM allows determination of commonalities that may be useful in training, training device, and test design and development. It can also be used to support MOS management decisions. The GJPM concept is a systematic approach that can point out areas of commonalities not previously apparent and, conversely, can identify areas of differences where commonalities were once assumed.

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SECTION I

INTRODUCTION

Background

Today's Army must operate in an environment characterized by advanced technology, complex, sophisticated weapons and operational systems, increased emphasis on combat support elements, and high dependency on automation. These changes have had a profound effect on how training requirements are defined, analyzed, and implemented.

Army training experienced a major revolution during the late 1960s and early 1970s. Performance-based training and testing, based on critical job tasks and criterion-referenced standards of performance, were being implemented in entry-level training courses. As early as 1973, the Army was engaged in defining a proceduralized model for instructional systems development (Branson, 1978). These efforts by the U.S. Army Combat Arms Training Board (CATB) at Ft. Benning, Georgia, led eventually to the Interservice Procedures for Instructional Systems Development (IPISD). The IPISD is now the standard document for development of military instruction.

One of the major requirements of an instructional model is the classification of behavior. It must be classified in a manner sufficiently broad to allow generalization beyond its immediate application, yet precise enough in its terminology and behavioral descriptors to be interpretable by the training developer. The present research effort developed such a method and applied it to the development of Skill Qualification Test (SQT) written components for three avionics maintenance military occupational specialties (MOS).

Taxonomies

Ever since Bloom (1956) published his Taxonomy of Educational Objectives, research has been directed at defining methods for classifying human behavior into discrete categories. Taxonomies of behavior tend to be situationally specific (e.g., Miller, 1969), or directed toward a restricted domain, like psychomotor (e.g., West, 1957), or cognitive (e.g., Bloom, 1956).

Bownas and Cooper (1978) conducted a review of the behavioral taxonomy literature. This review was the first task in the Generalizable Job Proficiency Matrix (GJPM) contract and explored a wide range of taxonomic approaches and their application. The following several paragraphs are taken from the Bownas and Cooper review.

A taxonomy, or more precisely, a taxonomic system, is a set of rules for classifying elements into an organized structure of categories. The taxonomic structure is designed to have properties useful either for explaining variations among the attributes of the elements, or for relating characteristics of the elements to phenomena external to the system.

The nature of a taxonomy depends upon its intended use. The types of elements and the types of important relationships sought among elements determine the rules of classification which, in turn, determine the taxonomic structure. Ultimately, it is the researcher interested in categorizing observations who is responsible for selecting the optimal set of classificatory rules.

Taxonomies reviewed by Bownas and Cooper varied greatly depending on whether they were developed for employee selection (Theologus, Romashko, & Fleishman, 1970), for training design (Powers, 1977), for purely scientific research into the nature of human attributes (Guilford and Hoepfner, 1971), or solely to examine methods of developing taxonomies (Austin, 1974). The types of elements to be categorized varied according to these orientations as well, with some researchers focusing on basic cognitive abilities, some on physical or psychomotor functions, and some on non-ability constructs. Most researchers dealt with combinations of these factors.

Taxonomies are typically developed in one of two ways. Some researchers attempt to describe the entire range of human abilities, and seek to connect these abilities with job performance only after the relationships underlying the ability domain have been thoroughly explicated, typically by factor analytic procedures. Two research programs exemplify a further dichotomy within this latter approach. Fleishman's research on human abilities at the American Instituutes for Research (Theologus, Romashko, & Fleishman, 1970) focused primarily on psychomotor abilities which had been shown or were hypothesized to determine or affect work behavior. Researchers at the Educational Testing Service (ETS) on the other hand (French, 1973; Ekstrom, French, & Harman, 1975) focused exclusively on paper and pencil tests of cognitive ability that have not been directly linked to proficiency in a variety of jobs.

Other researchers focus on the tasks of a specific job and attempt to define major performance or behavioral element dimensions rationally (e.g., McCormick, Jeanneret, & Mecham, 1969; Powers, 1977; Cunningham, 1972). Their taxonomic elements are usually expressed in terms readily applicable to a variety of job settings and their taxonomic classes are task-oriented. The research effort described in this report is an example of the task-oriented taxonomic approach.

Avionics Maintenance

The domain of interest in the present program was avionics maintenance. Keeping today's inventory of aviation electronic equipment in operational condition requires a highly trained group of maintenance personnel. Personnel are trained to diagnose and repair faults on a subset of equipment within a major functional area such as communications or navigation.

Students are trained in basic electronics and MOS specific tasks to include familiarization with the operation, maintenance philosophy, and the technical manual troubleshooting and repair procedures for each piece of equipment within their MOS.

This approach to training places school trained technicians in the field in a minimum of time. However, with the inventory of avionics increasing so rapidly, technicians in the field are often required to repair equipment unfamiliar to them. Furthermore, technicians often encounter symptoms of faults not specially covered in technical manuals. Many technicians do not adequately understand the rules and superstructure required to be adaptive to the work environment outside the classroom.

More emphasis is needed on teaching the basic elements common across electronics maintenance tasks. Examples include operation and use of basic test equipment to perform basic electrical measurements, selection and use of hand tools, standard shop procedures, and safety precautions. Additional instruction related to basic component and circuit behavior would enable the student to develop a core set of basic skills and knowledges common to all electronics maintenance.

Generalizable Job Proficiency Matrix Concept

The generalizable job proficiency matrix (GJPM) concept defined by the Army Research Institute was developed to address generic job requirements. A job proficiency matrix is a matrix representation of the tasks performed in an MOS and the behavioral skill elements required to perform these tasks. Matrix cell values represent the contributions each behavioral element makes to performing each task.

The matrix enables identification of elements common to sets of tasks in an MOS. It provides a basis for relating proficiencies on separate tasks and distinct systems by first identifying and then analyzing the behavioral elements they share. Therefore, an evaluation of job proficiency can be more than a sum of discrete, independent task proficiency assessments. Development of the job proficiency matrix concept allows for a more complete evaluation of job proficiency.

A job proficiency matrix may be also useful for developing criterion referenced, performance oriented tests of tasks, and for drawing both task and job related inferences of soldier proficiency. The potential utility of such a matrix and its desired properties became apparent during the initial Skill Qualification Test (SQT) construction and validation efforts of the U.S. Army. SQTs are job relevant evaluations of a soldier's ability to perform in his MOS. SQTs test soldiers on their ability to perform critical job tasks, and are also used to infer soldiers' overall job proficiencies.

The orientation of the SQT program is that of a domain and criterion referenced testing system (Maier and Hirshfeld, 1978). A fundamental concern of such a system is the validity and generalizability of the information gained through testing. This involves a careful definition of the content domain, the specification of what is to be included in the test of that domain, and the desire to draw reasonable inferences about a soldier's ability on the specific tasks included in the test, as well as being able to generalize from the test to the overall job proficiency of that soldier.

A job proficiency matrix can be developed that focuses on the skills required for successful performance of a task. Identifying skills underlying successful task performance, however, is a difficult requirement. It is unlikely that subject matter experts can agree on the definition of a skill and on which skills underlie performance of particular tasks. Without sufficient confidence in one's ability to identify skills, the validity and reliability of measurement of individual task by skill cells is questionable.

Attention, therefore, was directed at more behaviorally defined elements required for successful task performance. Behaviors such as measure, adjust, connect, etc. can be viewed as actions that are applicable across specific tasks. Consensus among experts should be high as to which actions are applicable for each task step. Therefore, identifying behavioral elements is more direct than identifying skills underlying task performance. For this reason this initial empirical examination of a job proficiency matrix concept concentrated on behavioral elements rather than skills. The research effort focuses on three avionics maintenance MOSs:

- 35L Avionics Communication Equipment Repairer
- 35M Avionics Navigation and Flight Control Equipment Repairer
- 35R Avionics Special Equipment Repairer.

Products of this contract include:

- Generalizable troubleshooting guide
- Task by behavioral element matrices for each MOS
- Skill Qualification Test (SQT) written components for each MOS.

The following section describes the input data, the technical requirements, and the technical approach used by Honeywell in developing the above products.

SECTION II

TECHNICAL APPROACH

The contract work performed by Honeywell was done as a subcontractor to Personnel Decisions Research Institute (PDRI). The Honeywell effort consisted of four major tasks.

- Task 1 - Develop task by element matrices
- Task 2 - Develop selection criteria and select tasks and elements for testing
- Task 3 - Develop SQTs
- Task 4 - Evaluate required specificity of task analysis documentation

In order to perform the specified contract requirements, Honeywell obtained the following data prior to conducting the developmental tasks.

1. Soldier's Manuals for skill levels 1 and 2 of MOSs 35L, 35M, and 35R.

2. All technical manuals referenced in the Soldier's Manuals including manuals describing test equipment set-up and use, standard shop practices, and prime equipment technical manuals.

3. Lists of equipment that will not be referenced in next generation Soldier's Manuals.

4. Any available task analyses for skill levels 1 and 2 of MOSs 35L, 35M, and 35R.

Task 1 - Develop Task by Element Matrices

The objective of Task 1 was to construct task-by-element matrices for the tasks in three Army avionics MOSs--35L, 35M, and 35R. The matrices are characterized by rows defining the critical tasks in each MOS and columns specifying the behavioral elements involved in task performance. Once completed, these task-by-element matrices can provide users with a systematic method for identifying commonalities among tasks within and across MOSs based on behavioral content. Concurrent with the analysis activity, a generalizable troubleshooting guide was prepared for the Signal School. The guide provides an overview of the troubleshooting process. A copy of the guide is included in Appendix A.

The process followed in developing task-by-element matrices involved the following four major activities, each of which is described in more detail below.

- Review task data in Soldier's Manuals and technical manuals.
- Define behavioral elements.
- Enter task and element data in matrix format.
- Revise matrices--reanalyze and collapse elements into the most economical set of descriptors.

Review task data--Honeywell reviewed the Soldier's Manuals (SM) for each MOS. A Soldier's Manual contains the task title, conditions, standards, and a list of performance measures which outline the activities involved in task performance. Each performance measure references a technical manual which provides the soldier with detailed, step-by-step procedures for executing each performance measure. Every SM and technical manual in our data base was reviewed to gain a better understanding of the equipments maintained by each MOS, the tasks to be performed on each piece of equipment, the level of maintenance to be performed by skill level 1 and 2 technicians, and the test equipment required to perform the tasks.

Define behavioral elements--During the review process, each performance measure in the SM was reviewed in detail using the appropriate technical manual. Worksheets were prepared summarizing the behaviors in each performance measure. Each summary was reviewed by other team members in order to insure consistency in the analysis. Discrepancies were worked out in team discussions. The procedures used during these analyses were consistent with the basic guidelines for job and task analysis contained in TRADOC Circular 351-4.

Behavioral elements are the subtasks or steps (i.e., perceptions, decisions, or actions) that are required of the soldier for him to perform each task in the Soldier's Manual successfully. The behavioral elements, in this context, are equivalent to the behavioral competencies for mastering a behavioral objective (i.e., a critical task). The major thrust of the analysis process was concerned with the definition, identification, and characterization of these behavioral elements.

The behavioral elements had to be defined at a level of specificity interpretable and implementable by a training material or test developer. A behavioral element required the following basic properties:

- The element must convey enough information to the user that the key requirements of successful task performance are specifiable.

- The element must enable the user to identify common behaviors both within and across MOSs.

The elements defined during the analysis process were characterized as belonging to either one of two groups, equipment elements or behavioral elements.

Equipment elements are discussed first. Test equipment used in the maintenance of avionics systems provides capabilities defined by system function. It was viewed as more important to identify the functions and knowledges pertinent to classes of equipment than it was to identify specific locations of controls on the individual equipment items. Equipment requirements for testing avionics systems were found to be one means of measuring task and MOS commonality.

Set-up, connect, and operate voltmeter, for example, implies the maintenance person is responsible for identifying the controls and displays of that piece of equipment, how it should be connected to a unit under test (UUT), what information it will provide him, and the sequence of actions he must follow to utilize the equipment's capabilities. The element also implies knowledge of safe operating procedures. Therefore, elements such as "set-up, connect, and operate voltmeter" were included as common elements in the matrices. They were separated from the larger group of behavioral elements only because of their equipment orientation. However, these elements were treated the same as other behavioral elements during all subsequent analyses.

Behavioral elements generally consist of more than one discrete perception or action. While this makes them larger than truly unique "elements," a lower level of definition would not provide a useful basis for determining commonality. The key factor in determining how many distinct similar elements are required is whether the analysis process indicated some unique aspect of job performance associated with one candidate element that cannot be accounted for in the already identified element. The following is an example of such a distinction. Elements such as "adjust resistance with a multimeter" and "adjust resistance with an oscilloscope" were listed distinctly for reasons of differences in determination of the value; one requiring reading a meter dial, the other analysis of a waveform. These two requirements point out behavioral differences which would not be recognized had the performance element been listed as "adjust resistance." Table 2-1 is a list of the derived set of all behavioral elements.

Behavioral elements preceded by "measure" imply the use of proper techniques, equipment, and the knowledges associated with the parameter which makes the element distinct. "Adjust" elements are generally distinct in two ways, a parameter and a facility for measuring it. The elements "Identify symptom," "Identify faulty section, faulty stage, or faulty part" are indicators of the level of system theory knowledge required of a technician for performance of a given fault isolation task. Symptom identification implies "top level" working knowledge of a system while faulty part identification implies the technician has the knowledge to identify symptoms, faulty sections, stages within sections, and finally to troubleshoot the system to the component level. This type of troubleshooting requires a much deeper level of system theory understanding than determining if the system is working correctly or not. Elements preceded by "Interpret," "Calculate," "Select," "Review," and "Verify" indicate a requirement for the correct use of technical documentation, the ability to comprehend written fault isolation

TABLE 2-1. BEHAVIORAL ELEMENTS

Set up, connect & operate

- Voltmeter/multimeter
- Oscilloscope
- Signal generator
- Wattmeter
- Frequency counter/meter
- Frequency converter
- Power supply
- Pulse generator
- Frequency comparator
- Time mark generator
- Standing wave ratio indicator
- Transfer oscillator
- Square law detector
- Echo box
- Variable attenuator
- Variable transformer
- Recorder w/preamps
- Tape reader
- Decade synchro bridge
- Headset/microphone
- Modulation meter
- Decade resistor
- Spectrum analyzer
- Dummy load
- Attenuator
- 150 ohm resistor
- 10 K ohm resister
- Audio oscillator (TS 382/U)
- Simulator, antenna coupler
- Fuseholder
- Audio Generator
- Modulator
- Millival meter
- Demodulator
- Navigational coupler
- Navigation set mount
- Test facilities/maintenance kit
- Radio test set
- Module tester (AN/ARM-87)
- Radio interference measuring set
- Test set (AN/URM-120)
- Test set (TS-1967)
- VOR test set
- SCAS test set
- Pilot static system tester
- Pulse Power T.S.
- R.F. Power T.S.
- Inertial Navigation T.S.
- Gyro Stablize Platform T.S.
- Subassembly T.S.
- Bench T.S.
- T.S. Subassembly
- Gyro T.S.
- Electron Tube T.S.
- Attitude Reference Control T.S.
- Gyro & Compass Signal Simulator
- Gyro Instrument/Tilt Table
- Precise Angle/Angle Position Ind.
- Decade Capacitor
- Gyro Stablized Platform Test Stand
- Computer Mount
- Purge & Fill Unit
- Stop Watch
- Test Tapes
- Thermistor Mount
- Antenna Mounting Fixture
- Carriages
- Slotted Section
- Probe
- Battery
- Test Facilities Kit
- Pulse Power Calibrator Meter
- RF Power Meter
- Differential Voltmeter
- Horizontal Situation Indicator (HSI)
- Digital Voltmeter
- Transistor T.S.
- Amplifier T.S.
- Direction finder T.S.
- Stabilization equipment T.S.
- Rotary actuator T.S.
- Attitude heading reference T.S.
- Accelerometer T.S.
- Reference control tester
- Gyro-magnetic T.S.
- Electron tube T.S.
- Radar altimeter T.S.
- TACAN T.S.
- Radar T.S.
- Transponder T.S.
- Simulator T.S.

TABLE 2-1 (Cont)

Measure:

- Suppression Count
- Degrees w/syncro bridge
- Angular speed (^{O}/sec)
- Time
- Voltage
- Resistance
- Current
- Power
- Frequency
- Continuity
- Waveform Characteristics
- Distortion
- Frequency Deviation
- Mechanical/angular position
- Vacuum Tube Characteristics
- Leakage (Rate)
- Statė gain
- Capacitance
- Output

Identify:

- Symptom
- Faulty Section
- Faulty Stage
- Faulty Part/Component

Interpret:

- Fault Isolation Tables/Charts
- Schematics/Wiring/Test Point Diagrams
- F.I. Charts/Tables
- Mechanical Diagrams

Calculate:

- Radio set distortion
- S/N - S+N/N Ratios
- Difference Frequency
- Percent Modulation
- Bandwidth
- Slaving Rate
- Static Settling Points
- Settling Point Difference
- RMS Scale Error
- Heading Change
- Latitude Drift Rate
- Change (Δ) Heading Limits
- Attitude Change
- Pitch/Roll Excursion
- Stage Gain
- Total Loop Attenuation
- Cable Length
- Average Power Out
- Difference Voltage
- Peak Power
- Receiver Sensitivity
- Sideband W/Cal. Curves
- Center Frequencies
- Power W/Calibration Curves
- (Signal + Noise) / Noise
- Drift Rate (in A R C Minutes)
- Signal/Noise Ratio
- Required Adjustment

Remove/Replace:

- Covers, Panels, Housing
- Lamps
- Trays
- Gears/Gear Train
- Subassembly/Module
- Circuit Board/Card
- Component
- Cables - Wiring
- Screws
- Fasteners
- Washer
- Pin
- Nuts/Bolts
- Filter
- Connectors
- Worn Parts
- Memory Drum Pins
- Knobs
- Coaxial Cables
- Soldered Leads/Harness
- Electron Tubes
- Cams
- Ball Bearings

- Panel Lights
- Meters
- Soldered Components
- Soldered Semi- conductors
- Soldered Covers
- Retaining Ring
- Gaskets
- Soldered Leads/Harness
- Pad, Filter
- Load
- Stable Element
- Clamps
- Handling Fixture
- Safety Block

Monitor:

- Audio Signal on Headset
- Test Set Displays/Indicators
- UUT Displays/Indicators
- Signal Generator
- Standing Wave Indicator
- Recorder Waveform
- Multimeter

Adjust:

- Resistor
- Resistance W/Oscilloscope
- Resistance W/Meter
- Resistor W/Test Set Displays
- Resistor W/UUT Display
- Resistance W/Multimeter
- Resistance W/Headset
- Resistance W/Angular Speed
- Variable Resistors
- Inductor W/Tuning Wand
- Inductor W/Oscilloscope
- Inductor W/Wand and Meter
- Inductor W/Multimeter
- Inductor W/Frequency Meter
- Inductor W/ Headset
- Transformer W/Wand and Scope
- Transformer W/Meter
- Transformer W/Oscilloscope
- Capacitor(s)
- Capacitance W/Frequency Meter
- Capacitance W/Voltmeter
- Capacitance W/Oscilloscope
- Capacitance W/Meter
- Capacitance W/Headset
- Capacitor W/Test Set Displays
- Testset Controls W/Multimeter
- Testset Controls W/Oscilloscope
- Testset Controls W/Headset
- Testset Controls W/UUT Display
- Connector Body W/Meter

(cont.)

TABLE 2-1 (Cont)

Adjust: (cont.)

Output W/Testset Display
Tuning Screw W/Oscilloscope
Gear W/Meter
Crystal Drums W/Meter
Pressure W/Gauge
Drift Bias
Antenna Position
Resolver
UUT Controls
Tuner Transformers
Mechanical Alignment
Cams/Slipclutch
Thermal Delay Relay

Connect/Disconnect:

Cables
Electrical Connectors
Coaxial Connectors
Pressure Line
Electric Components

Apply:

Sealing Compound
Heat Conducting Compound
Lubricant

Review Symptom List
Repair Wiring
Assemble/Disassemble UUT
Record Test Results in Digital Format
Perform UUT Adjustments
Solder/Desolder Components/Wiring
Perform Signal Substitution
Select Component
Check Part Value & Operation
Check Mechanical Operation
Disconnect/Connect Mechanical Linkage

Test Transistor W/Tester
Test Tube W/Test Set
Verify Correct Performance Param.
Align Synchro
Load and Run Tapes
Fabricate Cables
Open/Close Valves
Perform Leak Test
Check Blower Operation
Check Diodes
Check Circuitry
Tag the Leads/Wires
Insert Switch Shaft
Dismount Heat Sinks
Apply Lubricant
Break/Apply Cement
Wrap the New Part
Clean Circuit Board
Apply Varnish
Inspect

Select Components/Valves
Fabricate Test Circuit (Diode)
Solder/Desolder Parts/Components
Test Transistor W/Tester
Select Components/Valves
Test Tube W/Test Set
Visual Inspection
Drill Hole in Cam & Shaft
Fabricate & Install Shims
Safety Wire Components
Identify Resistance by Color Code
Stripwire W/Thermal Stripper
Verify Blower Operation
Check Continuity

(cont.)

TABLE 2-1 (Cont)

Apply: (cont.)

Remove & Apply Circuit Card Protective Coating

Mix Lubricant

Torque Fasteners

Clean Gasket & Mate Surface

Store Assembly on Foam Pad

Pressurize Unit

Check sweep sync

Check rf Source Marker

Check IF Output

Loosen/Tighten: Screws,Nuts

Scrape RTV/Coat with RTV

procedures and instructions, and the use of computations for fault isolation. While these behaviors are common to maintenance of dissimilar systems, and may not provide a basis for determining different levels of commonality between similar systems, they do identify important requirements for measuring performance capability. The remaining elements are generally manipulative in nature; "Remove and replace," "Repair," "Apply," "Assemble/ Disassemble," etc., and are included for task comparison on the basis of the knowledges required for their correct performance.

Enter task and element data--The concept of a generalizable job proficiency matrix is relatively straightforward. Along one dimension of the matrix are the critical tasks (i.e., the technical tasks) which define the particular MOS (e.g., Avionics Navigation and Flight Control Equipment Repairer). For this analysis, we were only concerned with the critical MOS tasks for both skill levels 1 and 2 and not the common soldiering tasks (e.g., first aid). Behavioral elements are included in the second dimension of the matrix.

The behavioral element and task data were entered into the matrix, tasks vertically and behavioral elements horizontally. For each element that is part of a task, an "x" was entered into the matrix (only one "x" per element/per task). These matrices provided the format for analyzing common behavioral elements within and between MOSs for the various equipments maintained. The task by element matrices for MOSs 35L, 35M, and 35R are contained in Appendix B.

Task lists were grouped into three categories of tasks for both skill levels. The categories were: troubleshooting or fault isolation, align/adjust, and remove/replace. The hypothesis being that behaviors involved in troubleshooting with one MOS would be more similar to troubleshooting behaviors in the other two MOSs than to remove and replace behaviors even within the same MOS. The categorization format also served to make the matrix more readable and interpretable.

Revise matrices--After a preliminary draft of each matrix was constructed, it was shown to a team of subject matter experts at the Signal School and at Honeywell. Discrepancies, inconsistencies, and technical errors were eliminated. Definitions of elements were changed; some elements were merged into more general descriptors; some were further broken down until a consistent economical set of descriptors was developed. This procedure was then repeated for the other two MOSs. After each succeeding MOS was studied, further revisions were carried out on the initial matrix.

Task 2 - Develop Selection Criteria and Select Tasks and Elements for Testing

The task by element matrices developed in Task 1 identified commonalities within and across MOSs. Because the Signal School had to select tasks for testing on the SQTs for 35L, 35M, and 35R shortly after the beginning of this contract, it was not possible to apply the matrix for task selection on these particular SQTs. However, recommendations were made for testing based on the completed matrices. These recommendations can be used by the Signal School in subsequent SQT development or revised versions of the existing tests.

Even though the matrix concept was not applied directly to task selection, it was used successfully in the identification of those performance measures (steps) within a task that are most critical to overall task performance. Therefore, individual items in scorable units (task based tests) were in fact developed based on the behavioral elements necessary for successful task performance. Because the contract called for the development of written SQTs, the behavioral elements and tasks recommended for testing had to be amenable to written or pictorial formats.

Though the MOS tasks and elements recommended for testing were identified through matrix analysis, other factors were considered as well. These included: critical personnel or equipment hazard precautions, field maintenance data identifying high failure components (systems), and training deficiencies.

Task 2 produced two prioritized lists, one of tasks and one of behavioral elements. The element list consisted of those elements most amenable to testing in a written or pictorial format. Identication of elements required in many tasks was critical to the development of the prioritized task list. The task list was prioritized on how many and what combination of behavioral elements of an incumbent's job were required in task performance.

<u>Commonality analysis</u>--The behavioral elements were analyzed for commonality according to the number of systems each element supports. Because MOSs are assigned responsibility for systems rather than individual tasks, frequencies were tabulated for elements on a systems basis. Elements occurring relatively infrequently were not included in the revised list of elements.

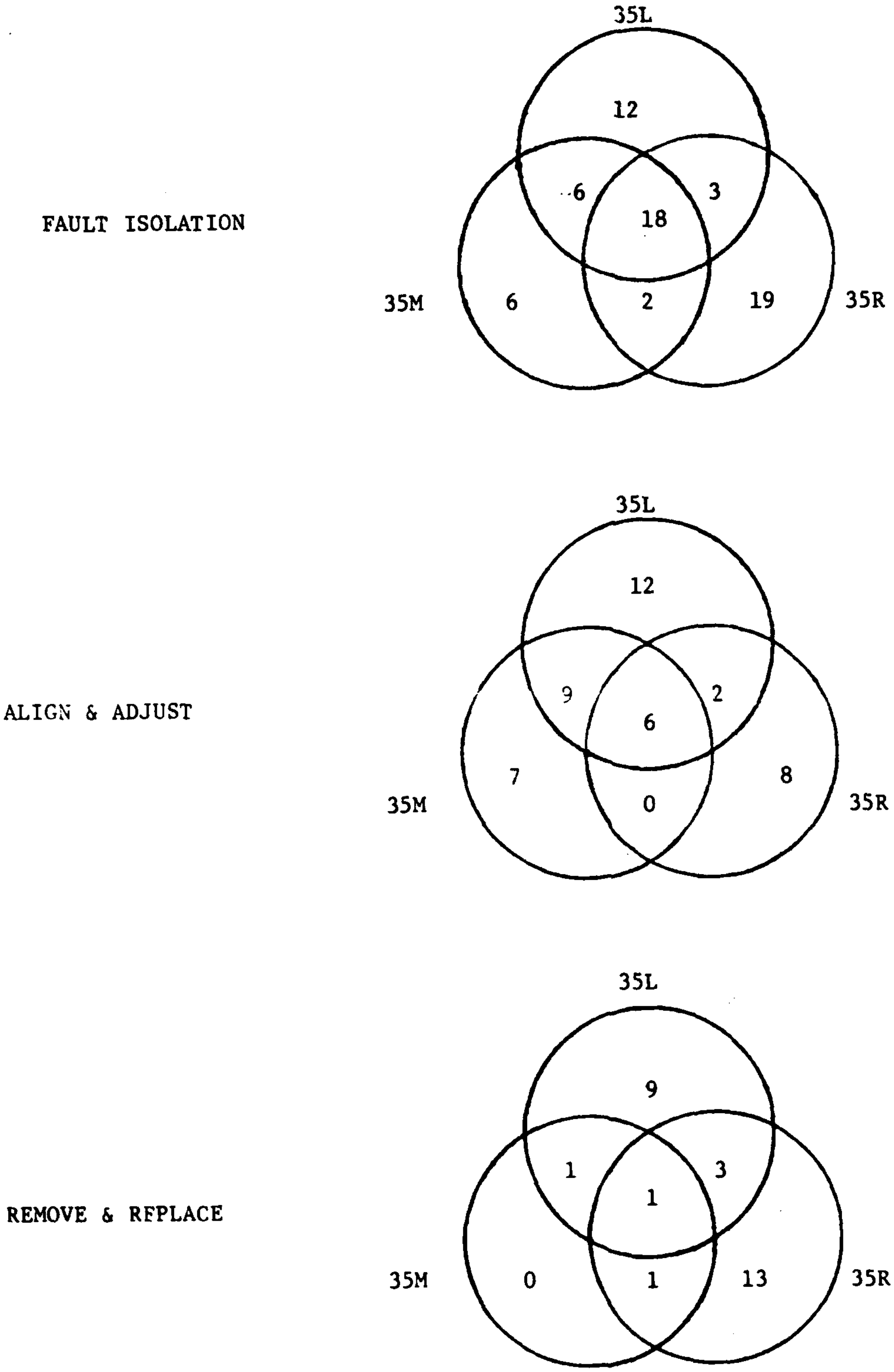
A cutoff point for inclusion in the final list of common elements was determined by evaluating the number and type of systems, the number of systems each element supports, and the resulting element list length. These criteria were applied iteratively, and relied heavily on the developer's knowledge of avionics maintenance job requirements. The set of behavioral elements was reviewed by Army subject matter experts at the Signal School and revised based on their recommendations.

The resulting task by element matrices were used to identify commonality within and across MOSs. Table 2-2 lists the equipment responsibilities of each MOS. By grouping equipment based on its function, estimates of commonality were derived within and across MOSs. Figure 2-1 contains Venn diagrams illustrating the commonality of MOSs 35L, 35M, and 35R. Commonality is defined in terms of behavioral elements shared by MOSs. It may be observed that 35L and 35M have more in common with each other than either has with 35R, particularly in the areas of fault isolation and align and adjust.

Tables 2-3, 2-4, and 2-5 list those common element occurrences for each of the MOSs. The columns F (fault isolate), A (align and adjust), and R (remove and replace) show the occurrence of elements in those maintenance type classifications. It is clear from these tables that fault isolate and align and adjust tasks are highly related. Table 2-6 lists elements occurring in all three of the MOSs and the columns show the occurrence by MOS and maintenance type. The table allows identification of elements common to MOS, maintenance type, or some combination of these. Table 2-7 is a list of elements which occur in the same maintenance classification of any two, or all three, MOSs.

TABLE 2-2. EQUIPMENT BY MOS

MOS 35L	Nomenclature
AN/ARC-51BX	Radio set
AN/ARC-54	Radio set
AN/ARC-102	Radio set
AN/ARC-114	Radio set
AN/ARC-115	Radio set
AN/ARC-116	Radio set
AN/ARC-131	Radio set
AN/ARC-134	Radio set
AN/ARC-164	Radio set
C-1611/AlC	Control, intercommunication set
C-3940/ARC-94	Control, radio set
C-6533/ARC	Control, communication system
MOS 35M	
AN/ARN-30	Receiving set, radio
AN/ARN-59	Direction finder set
AN/ARN-82	Radio receiving sets
AN/ARN-83	Direction finder set
AN/ARN-89	Direction finder set
AN/ARN-123	Radio receiving sets
AH-1 SCAS	Stability control augmentation system (helicopter)
A2/J2 compass	Compass
AN/ASN-43	Gyromagnetic compass set
AN/ASN-76	Attitude-heading reference set
AN/ASW-12	Automatic flight control system
CH47 SAS	Stability and control augmentation system
CH47 Spd TRIM AMP	Automatic speed trim amplifiers
CV-1275/ARN	Converter radio-magnetic indicator
R-1963/ARN	Radio receiver
R-1041/ARN	Receivers, radio
MOS 35R	
AN/APM-305A	Test set, transponder set
CP941/ASN-86	Program load computer
RT-711/APN-158	Radar set
RT-804/APN-171	Altimeter set, electronic
RT-895/APX-72	Transponder
RT-1057/ARN-103	Navigational set, TACAN



NOTE: Number values represent numbers of elements in each group.

Figure 1. Element Commonality by MOS and Maintenance Type

TABLE 2-3. MOS35L COMMON ELEMENTS

35L COMMON ELEMENTS	F	A	R
Set-up, Connect, and Operate:			
Voltmeter/multimeter	x	x	
Oscilloscope	x	x	
Frequency counter/meter	x	x	
Wattmeter	x	x	
Signal generator	x	x	
Spectrum analyzer	x	x	
Attenuator	x	x	
Power supply	x	x	
Headset/microphone	x	x	
Modulation meter	x	x	
Test facilities/maintenance kit	x	x	
Radio test set	x	x	
Measure:			
Voltage	x	x	
Resistance	x		
Current	x		
Power output	x	x	
Frequency	x	x	
Continuity	x		
Waveform characteristics	x	x	
Distortion	x		
Frequency deviation	x		
Identify:			
Symptom	x		
Faulty section	x		
Faulty part	x		
Interpret:			
Fault isolation tables/charts	x		
Schematics/wiring/test point diagrams	x		
Calculate gain	x		
Monitor:			
Audio signal w/headset	x	x	
Test set displays	x		
Unit-Under-Test (UUT) displays	x		

F - fault isolate

A - align & adjust

R - remove & replace

TABLE 2-3 (Cont)

	F	A	R
<u>35L COMMON ELEMENTS</u> (continued)			
Adjust:			
Capacitance w/voltmeter		x	
Capacitance w/oscilloscope		x	
Resistance w/multimeter	x	x	
Resistance w/oscilloscope	x	x	
Resistance w/headset		x	
Inductor w/multimeter		x	
Test set controls w/multimeter		x	
Mechanical alignment		x	x
Remove and Replace:			
Covers/panels			x
Circuit cards	x	x	x
Knobs			x
Ballbearings			x
Screws			x
Nuts/bolts			x
Panel lights			x
Modules/subassemblies	x	x	x
Coaxial cables			x
Soldered:			
Leads/harness			x
Components	x	x	x
Electrical connectors			x
Select components/values	x	x	
Review symptom list	x		
Repair wiring	x		
Record test results in digital format	x		

TABLE 2-4. MOS35M COMMON ELEMENTS

35M COMMON ELEMENTS	F	A	R
Set-up, Connect, and Operate:			
Voltmeter/multimeter	x	x	
Oscilloscope	x	x	
Frequency counter/meter	x	x	
Wattmeter	x	x	
Signal generator	x	x	
Power supply	x	x	
Radio test set	x	x	
Pitot-static system tester	x	x	
Gyro-instrument tilt table	x	x	
Decade resistor	x	x	
Measure:			
Voltage	x	x	
Resistance	x		
Continuity	x	x	
Waveform characteristics	x		
Time	x	x	
Identify:			
Symptom	x		
Faulty section	x		
Faulty stage	x		
Faulty part	x		
Interpret:			
Fault isolation tables/charts	x		
Schematic/wiring/test point diagrams	x		
Calculate gain	x		
Monitor:			
Audio signal w/headset	x	x	
Test set displays	x		
Unit-Under-Test (UUT) displays	x		

F - fault isolate

A - align & adjust

R - remove & replace

TABLE 2-4 (Cont)

	F	A	R
<u>35M COMMON ELEMENTS</u> (continued)			
Adjust:			
Capacitance w/voltmeter		x	
Resistance w/multimeter	x	x	
Transformer w/multimeter		x	
Test set controls w/multimeter		x	
Mechanical alignment		x	
Gyro tilt table	x		
Remove and Replace:			
Screws	x	x	x
Modules/subassemblies	x		x
Soldered components	x	x	
Select components/values	x	x	
Test tube w/tester	x		
Apply lubricant			x

TABLE 2-5. MOS35R COMMON ELEMENTS

	F	A	R
35R COMMON ELEMENTS			
Set-up, Connect, and Operate:			
Voltmeter/multimeter	x	x	
Oscilloscope	x	x	
Frequency counter/meter	x	x	
Wattmeter	x	x	
Signal generator	x	x	
Power supply	x		
Pulse generator	x	x	
Radar test set	x	x	
Transponder test set	x	x	
Stopwatch	x		
Headset	x		
Battery	x		
Measure:			
Voltage	x		
Resistance	x		
Power output	x		
Frequency	x		
Waveform characteristics	x	x	
Time	x		
Identify:			
Symptom	x		
Faulty part	x		
Interpret:			
Fault isolation tables/charts	x		
Schematics/wiring/test point diagrams	x		
Mechanical diagram			x
Calculate:			
Gain	x		
Total loop attenuation	x		

F - fault isolate

A - align & adjust

R - remove & replace

TABLE 2-5 (Cont)

35R COMMON ELEMENTS (continued)	F	A	R
Monitor:			
Test set displays	x		
Unit-Under-Test (UUT) displays	x		
Signal generator	x		
Recorder waveform	x		
Adjust:			
Resistance w/multimeter	x	x	
Resistance w/test set displays	x	x	
Resistance w/UUT display	x		
Resistance w/oscilloscope		x	
Test set control w/UUT display	x		
Test set control w/multimeter	x		
Unit-Under-Test (UUT)	x		
Remove and Replace:			
Covers/panels	x	x	x
Circuit cards			x
Modules/subassemblies	x	x	
Coaxial cables	x		
Components	x		x
Fasteners			x
Clamps			x
Connector pins			x
Lamps	x		
Loosen/tighten screws/nuts		x	
Connect/disconnect cable		x	
Connect/disconnect electrical connectors			x
Assemble/disassemble UUT		x	
Check continuity	x		
Check blower operation	x		
Verify correct performance parameters	x		
Apply lubricant			x
Torque fasteners			x
Stripwire w/thermal stripper			x

TABLE 1. ELEMENTS COMMON ACROSS MOSs

MOS	35L			35M			35R		
Maintenance Type	F	A	R	F	A	R	F	A	R
Set-up, Connect, and Operate:									
Voltmeter/multimeter	x	x		x	x		x	x	
Oscilloscope	x	x		x	x		x	x	
Frequency counter/meter	x	x		x	x		x	x	
Wattmeter	x	x		x	x		x	x	
Signal generator	x	x		x	x		x	x	
Power supply	x	x		x	x		x		
Pulse generator							x	x	
Radar test set							x	x	
Transponder test set							x	x	
Radio test set	x	x		x	x				
Pitot-static system tester				x	x				
Test facilities/maintenance kit	x	x							
Modulation meter	x	x							
Headset/microphone	x	x					x		
Gyro-instrument tilt table				x	x				
Decade resistor				x	x				
Stopwatch							x		
Battery							x		
Attenuator	x	x							
Spectrum analyzer	x	x							
Measure:									
Voltage	x	x		x	x		x		
Resistance	x			x			x		
Power output	x	x					x		
Frequency	x	x					x		
Waveform characteristics	x	x		x			x	x	
Time				x	x		x		
Continuity	x			x	x				
Distortion	x								
Frequency	x								
Frequency deviation	x								
Current	x								
Identify:									
Symptom	x			x			x		
Faulty part	x			x			x		
Faulty section	x			x					
Faulty stage				x					

F - fault isolate

A - align & adjust

R - remove & replace

TABLE 1 (cont)

MOS	35L			35M			35R		
Maintenance Type	F	A	R	F	A	R	F	A	R
Interpret:									
Fault isolation tables/charts	x			x			x		
Schematics/wiring/test point diagrams	x			x			x		
Calculate:									
Gain	x			x			x		
Total loop attenuation							x		
Monitor:									
Audio signal w/headset	x	x		x	x				
Test set displays	x			x			x		
Unit-Under-Test (UUT) displays	x			x			x		
Signal generator							x		
Recorder waveform							x		
Adjust:									
Capacitance w/voltmeter		x			x				
Capacitance w/oscilloscope		x							
Resistance w/multimeter	x	x		x	x		x	x	
Resistance w/oscilloscope	x	x						x	
Resistance w/headset		x							
Resistance w/test set displays							x	x	
Resistance w/UUT displays							x		
Transformer w/multimeter					x				
Test set controls w/multimeter		x			x		x		
Test set controls w/UUT display							x		
Inductor w/multimeter		x							
UUT		x	x		x				
Gyro tilt table				x					
Remove and Replace:									
Covers/panels			x				x	x	x
Circuit cards	x	x	x						x
Knobs			x						
Ballbearings			x						
Screws			x	x	x	x			
Nuts/bolts			x						
Panel lights/lamps			x				x		
Modules/subassemblies	x	x	x	x		x	x		x
Coaxial cables			x				x		

TABLE 1 (cont)

MOS	35L			35M			35R		
Maintenance Type	F	A	R	F	A	R	F	A	R
Remove and Replace (continued)									
Soldered:									
Leads/harness			x						
Components	x	x	x	x	x				
Components							x		x
Fasteners									x
Clamps									x
Connector pins									x
Connect/disconnect:									
Cables								x	
Electrical connectors			x						x
Select components/values	x	x		x	x				
Review symptom list	x								
Repair wiring	x								
Record test results in digital format	x								
Test tube w/tester				x					
Apply lubricant						x			x
Loosen/tighten screws/nuts								x	
Assemble/disassemble UUT								x	
Check continuity							x		
Check blower operation							x		
Verify correct performance parameters							x		
Torque fasteners									x
Stripwire w/thermal strippers									x

TABLE 2. ELEMENTS COMMON TO 2/3 MOSs

Set-up, Connect, and Operate:

- Voltmeter/multimeter
- Oscilloscope
- Frequency counter/meter
- Wattmeter
- Signal generator
- Power supply
- Radio test set
- Headset microphone

Measure:

- Voltage
- Resistance
- Power output
- Frequency
- Waveform characteristics
- Time
- Continuity

Identify:

- Symptom
- Faulty section
- Faulty part

Interpret:

- Fault isolation tables/charts
- Schematic/wiring/test point diagrams

Calculate gain

Monitor:

- Audio signal w/headset
- Test set displays
- Unit-Under-Test displays

Adjust:

- Capacitance w/voltmeter
- Resistance w/multimeter
- Resistance w/oscilloscope
- Test set controls w/multimeter
- Mechanical alignment

TABLE 2 (cont)

Select components/values

Apply lubricant

Connect/disconnect electrical connectors

Remove and Replace:

- Covers/panels
- Circuit cards
- Screws
- Modules/subassemblies
- Soldered components

Task prioritization--The MOS common elements were noted on each of the matrices and the occurrence of common elements in each task was used to prioritize the tasks. The resulting task lists, one for each maintenance type of each MOS, show which tasks best characterize the behavior requirements of the MOS incumbents. Furthermore, all common elements can be included in an SQT, because tasks can be readily identified in which these elements occur.

Tables 2-8, 2-9, and 2-10 list the prioritized tasks for each MOS, by task number. These numbers correspond to the task numbers contained in the current 35L, 35M, and 35R Soldier's Manuals.

An additional list was developed of elements amenable to written testing. Elements of behavior dealing with understanding, perception, and judgment are most appropriate for written testing. Elements requiring manipulation of tools, components, or alignment of parts would be further analyzed in Task 3 to determine if cognitive aspects existed which were testable. For example, manipulative elements may require knowledge of operation sequence, interpretation of alignment, or observation of safety procedures. These could be tested and so part of the behavior requirements could be measured. Table 2-11 lists the elements, or portions of elements, thus identfied.

Task 3 - Develop SQTs

Honeywell developed written components of SQTs for MOSs 35L, 35M, and 35R. Scorable unit construction followed directly from the detailed analyses developed in the earlier tasks. Avionics experts employed by Honeywell's Avionics Division assisted in the SQT construction.

TABLE 2-8. MOS35L PRIORITIZED TASK LIST

FAULT ISOLATION

35L10	35L20
113-586-0003	113-586-0103
-0008	-0104
-0007	
-0043	
-0006	
-0046	
-0011	
-0012	
-0014	
-0024	
-0025	
-0045	
-0047	
-0042	
-0108	
-0005	
-0002	
-0004	
-0009	
-0032	
-0102	
-0106	
-0013	
-0033	
-0038	
-0001	
-0016	
-0141	
-0010	
-0031	
-0044	
-0107	
-0015	
-0034	
-0035	
-0039	
-0105	
-0101	

Note: Soldier's Manual Task Numbers

TABLE 2-8 (Cont)

ALIGN AND ADJUST

35L10	35L20
113-586-5010	113-586-5060
-5007	-5043
-5021	-5058
-5002	-5038
-5061	-5069
-5051	-5025
-5001	-5026
	-5044
	-8033
	-5015
	-5045
	-5057
	-5019

TABLE 2-8 (Cont)

REMOVE AND REPLACE

35L10	35L20
113-586-4027	113-586-4040
-4065	-4047
-4022	-4070
-4038	-4076
-4002	-4119
-4023	-4050
-4032	-4051
-4039	-4020
-4067	-4100
-4119	-4057
-4025	-4042
-4031	-4044
-4058	-4045
-4088	-4052
-5065	-4108
	-4102

TABLE 2-9. MOS35L PRIORITIZED TASK LIST

FAULT ISOLATION

35M10	35M20	
113-585-0065	113-585-0219	-0106
-0042	-0220	-0201
-0044	-0221	-0209
-0063	-0202	-0214
-0040	-0222	-0215
-0066	-0218	-0096
-0011	-0216	-0199
-0041	-0203	-0207
-0077	-0206	-8031
-0084	-0026	-8032
-0009	-0027	-8033
-0043	-0030	-8035
-0095	-0032	-8036
-0001	-0033	-8039
-0006	-0034	-0018
-0012	-0035	-8029
-0013	-0181	-8030
-0016	-0192	-8037
-0056	-8034	-8038
-0045	-0020	-8040
-0048	-0179	-0186
-0062	-0184	
-0078	-0193	
-0079	-0208	
-0085	-0217	
-0086	-0019	
-0087	-0021	
-0088	-0022	
-0089	-0023	
-0002	-0024	
-0003	-0025	
-0004	-0028	
-0005	-0029	
-0007	-0090	
-0008	-0180	
-0039	-0182	
-0094	-0183	
-0055	-0205	
-0080	-0213	
-0081	-0017	
-0082	-0091	
-0037	-0092	
-0074	-0093	
-0038	-0185	

NOTE: Soldier's Manual Task Numbers

TABLE 2-9 (Cont)

ALIGN AND ADJUST

35M10	35M20
113-585-5014	113-585-5077
-5015	-5078
-5023	-5052
-5040	-5053
-5022	-5076
-5005	-5065
-5007	-5067
-5024	-5055
-5036	-5056
-5037	-5068
-5069	-5058
-5070	-5062
-5003	-5057
-5006	-5060
-5009	-5061
-5021	-5064
-5025	-5066
-5004	-5071
-5008	-5054
-5011	
-5031	
-5032	
-5033	
-5038	
-5039	
-5074	
-5075	
-5027	
-5028	
-5013	
-5072	
-5073	
-5002	
-5010	
-5034	
-5035	
-5029	
-5001	

TABLE 2-9 (Cont)

REMOVE AND REPLACE

35M10

113-585-4004
-4009
-4027
-4002
-4003
-4008
-4001
-4016

TABLE 2-10. MOS35R PRIORITIZED TASK LIST

FAULT ISOLATION

35R10

113-610-0083
-0026
-0033
-0038
-0027
-0084
-0028
-0029
-0032
-0045
-0044
-8012
-0082
-0030
-0046
-0043

35R20

113-610-0042
-0041
-0040
-8009
-8010

Note: Soldier's Manual Task Numbers

TABLE 2-10 (Cont)

ALIGN AND ADJUST

35R10	35R20
116-610-5019	113-610-5012
-5013	
-5015	
-5008	
-5009	
-5017	
-5014	

TABLE 2-10 (Cont)

REMOVE AND REPLACE

35R10	35R20
113-610-4019	113-610-4022
-4012	-4128
-4020	-4043
-4014	-4127
-4015	
-4016	
-4017	
-4029	
-4174	
-4028	
-4013	

TABLE 2-11. COGNITION ELEMENTS

Identify:

- Symptom
- Faulty section
- Faulty part

Interpret:

- Fault isolation tables/charts
- Schematic/wiring/test point diagrams

Calculate gain

Monitor:

- Test set displays
- Unit-Under-Test displays

Select components/values

<u>COGNITIVE PORTIONS OF OTHER ELEMENTS</u>

Set-up, connect, and operate equipment

Measure parameters

Adjust parameters

Remove and replace hardware

Monitor audio signal

The goal of the SQT program is to provide an equitable, reliable and job relevant testing instrument for determining the proficiency of enlisted soldiers. The SQT must be task oriented and focus on behaviors with measurable outcomes. Honeywell developed the three final written components in accordance with the Individual Training and Evaluation (ITE) Directorate procedures and specifications for the development, editing, and production of skill qualification tests as stated in Chapter 5 of SQT GUIDELINES, 1 December 1977. HumRRO conducted a five-day workshop at Honeywell during the beginning of the development process to insure that the SQTs would be consistent with current guidance, procedures, and policy.

The HumRRO workshop resulted in the generation of fifteen sample scorable units (SU), five for each of the three MOSs. The sample scorable units were reviewed by HumRRO, the Signal School, and the Individual Training and Evaluation (ITE) directorate at Ft. Eustis. Review of the scorable units led to the following recommendations that were incorporated in all subsequent SU development.

- Increase the use of personal pronouns
- Consider including some part of the situation as part of the question narrative
- Keep the reading level at or below seventh grade ability
- Consider supporting questions with line drawings or photographs.

During a four month effort Honeywell developed 91 scorable units (SU) required by the test plans for MOSs 35L, 35M, and 35R. Four hundred ninety-nine (499) measurable items were generated with an average of 5.5 items per SU. The SQTs for MOSs 35M and 35R were submitted 25 August 1979, and the SQT for MOS 35L submitted 25 September 1979. All packages were delivered in camera ready form and included an index of SUs and an answer key. An iterative process of SQT development was followed. The steps involved are outlined below:

- identified all materials and references required for each scorable unit
- defined preliminary measurable items and any additional materials required
- developed initial drafts of SUs
- internally reviewed, critiqued, and edited each SU
- produced all necessary graphics and art work
- established a final format; final typed and printed all SQTs
- submitted the SQTs for Army review

Identify all materials--The first step in the SQT development process was to identify all materials and references required for each SU. Given the set of tasks selected for the written component, it was necessary to organize the Soldier's Manual task descriptions and all supporting technical material by scorable unit. Once completed, the definition of preliminary measurable items was initiated.

Define measurable items--Potential measurable items were selected on the basis of key elements. Key elements were isolated by studying the task procedures, the task by element matrices produced in Task 1, and the commonality analyses completed in Task 2. Developing the SQT around key elements insured that testing would concentrate on those aspects of task performance most critical to an incumbent's MOS duties. It also increased the face validity of the test and consequently its acceptance. Key elements for the written component were primarily tasks involving task elements having grave negative consequences if performed incorrectly (e.g., related to personnel and equipment safety), and other task elements whose consequences are not as extreme, but nevertheless are performed incorrectly with high frequency. The latter category of elements identify the major performance deficiencies. The SQT guidelines identify four basic areas of performance deficiencies. These relate to where, when, what, and how to perform. More specifically:

- Soldiers may not know <u>where</u> to perform a task. They may be having difficulty locating objects and differentiating between objects.
- Soldiers may not know <u>when</u> to perform a step. They may be unfamiliar with the sequence of activities in a given situation.
- Soldiers may not know <u>what</u> the product is for a given task. They may not realize what the result should be.
- Soldiers may not know <u>how</u> to perform a procedure. They may not remember the correct set of actions required to execute a task.

Another variable moderating the selection of key elements for testing was the behavioral element commonality analysis. Unique SUs were not always required for each task common across MOSs.

In many of these cases the same SU was used in more than one SQT. This facilitates more equitable scoring and standardization of written components by building on commonality.

Common behavioral elements occurring in many distinct tasks were not tested in every task. For example, if a key element had been satisfactorily covered in a previous scorable unit within the same MOS, it was not retested on all subsequent opportunities. This helped to reduce the total number of questions on an SQT and thus shortened the testing time required without reducing the generalizability of the test. It also offered the opportunity to test on a wider range of behavioral elements. This preliminary definition of measurable items also identified supporting documentation such as line drawings, schematics, and background material useful in drafting the SUs.

Develop draft scorable units--Once the potential test questions were selected, initial drafts of the SUs were generated. There are two basic modes of testing the key elements. The first mode is written performance. This type of question measures the examinee's ability to perform a task. The item requires the examinee to perform all steps of a task/task element as he would perform it on the job and to select the correct answers from a set of real world alternatives. The second mode of testing used is performance based. This type of question measures how an examinee would perform a task given a specific situation. When written correctly both modes of testing can provide a comprehensive evaluation of key elements. Of the two testing modes, performance based questions were written most frequently. This was due to the nature of the tasks and the limitations imposed by the written component environment. The following criteria define whether written performance or performance based items are appropriate:

1. Can the entire task be performed at the written component station?

2. Can a task element be performed at the written component station?

3. Can the correct task product be recognized without actually performing the task or task element?

The final criterion has a significant implication for the written component of the SQT. Questions are constrained by answers which are amenable to a multiple choice recognition response. That is, the examinee will read the question, formulate an answer, compare his answer with the list of alternatives, and select the alternative which corresponds with his answer. If the correct task product can be recognized from a list of alternatives without performing the task, there is no benefit in having him perform it.

When developing initial drafts of the measurable items, the correct answer was determined for a key element, the situation was described, the question written, and real-world alternatives were selected. Draft SUs consisted of two to ten measurable items.

<u>Conduct internal review</u>--Once a draft SU was completed, it was submitted for internal review. Honeywell SMEs used the following guidelines for critiques and editing.

- Technical accuracy: the right alternative is absolutely correct and the wrong alternatives are absolutely incorrect. Each measurable item has only one correct answer and is capable of distinguishing between performers and non-performers.

- Doctrinal accuracy: only task elements specified in or implied by the Soldier's Manual are tested.
- Items must test the application of knowledge rather than knowledge alone.
- The job situation provides only information necessary to establish the framework for the questions.
- Test language is as simple as possible, but does not omit routinely used technical terms and job language.
- Questions are written in the active voice.
- Art work and graphics are used appropriately.
- The letter code sequence of the correct answers is random and evenly distributed.
- Incorrect alternatives are common and/or reasonable errors. (The goal was to guarantee that if the examinee figures out a wrong answer, based on clearly incorrect yet plausible false assumptions, that it can be found among the alternatives presented.) Three to five alternatives were developed for each question.
- Items must be independently solved. This implies (a) the stem of one item should not cue the examinee to the answer in another item, (b) items should not contain cues to their own answers, (c) answers should not be interdependent.
- Items within an SU are ordered in operational sequence.
- Included are all necessary technical extracts that are authorized and routinely used on the job--(not to exceed thirty pages/SU).

Produce art work--After the draft scorable units were reviewed, all necessary graphics and art work were produced. To support the narratives, drawings, tables, diagrams, and schematics were used for presenting cues. This allowed the opportunity for innovative job oriented questions including:

- meter/scope reading
- test equipment setup and operation
- schematic interpretation
- observation of safety precaution
- module alignment
- component location/identification
- theory application.

Establish final format and submit SQTs to Signal School--Honeywell established a final format for the SQTs and final typed and printed the scorable units. Answer sheets and an index of SUs were included in the package that was submitted to the Army for review.

There are two basic modes of scorable units; written performance and performance based. There are five major categories of key elements related to incorrect task performance and adverse consequences of incorrect task performance. These categories include where, when, what, and how to perform, as well as personnel and equipment safety. Table 2-12 depicts the frequency with which various question types were written. Figure 2-2 is a set of sample measurement items representing the categories defined in Table 2-12. The completed SQT written components are not included because of their proprietary nature. In order to assure standardization and

TABLE 2-12. QUESTION TYPE FREQUENCY

Key Elements

Testing Mode	Incorrect Task Performance				Consequences of Faulty Task Performance
	Where to Perform	When to Perform	What the Product Is	How to Perform	Personnel & Equipment Safety
Written Performance	3.1%	0%	4.7%	10.4%	0%
Class-ification	I	II	III	IV	V
Performance Based	10.4%	18.2%	27.6%	22.4%	3.2%
Class-ification	VI	VII	VIII	IX	X

SAMPLE MEASUREMENT

ITEMS

Table 8
Classification

I. You are doing the zero altitude alignment on tracker card A1. Which resistor in figure 17-1 should you adjust for 0.000 ± 0.007 Vdc?

A. resistor A C. resistor C

B. resistor B D. resistor D

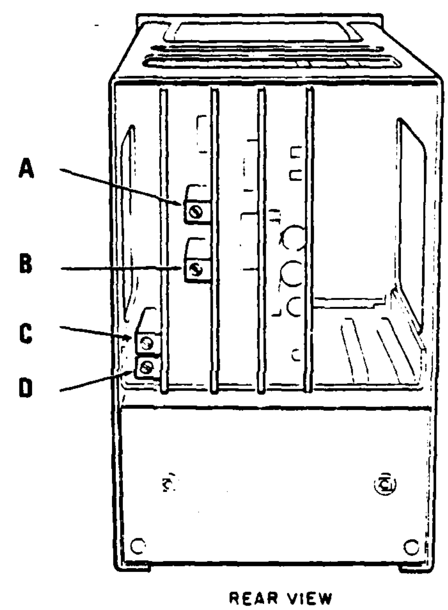


Figure 17-1

II. No measurement item.

Figure 2-2

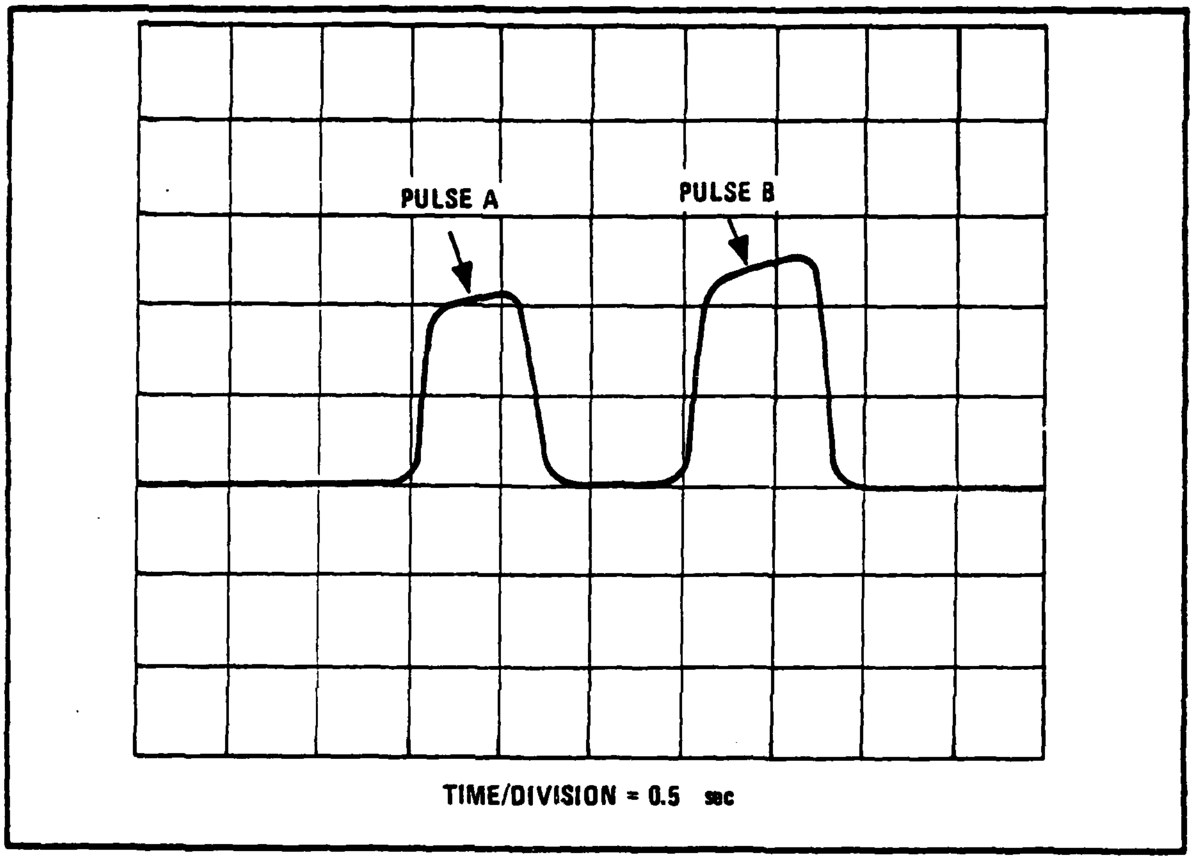


Figure 22-2

III. What is the pulse width of pulse A in figure 22-2 at the 50 percent amplitude point?

A. 0.50 sec

B. 0.65 sec

C. 0.75 sec

D. 1.00 sec

Figure 2-2 (cont.)

IV. You have connected the audio oscillator and VTVM to the appropriate test points to measure the stage gain of Q13. You have adjusted the signal output to 400 cps and an output level of 33 mv. You get a VTVM reading as shown in figure 15-2. What is the stage gain of Q13?

A. 0.047
B. 2.1
C. 6.0
D. 21.0
E. 26.0

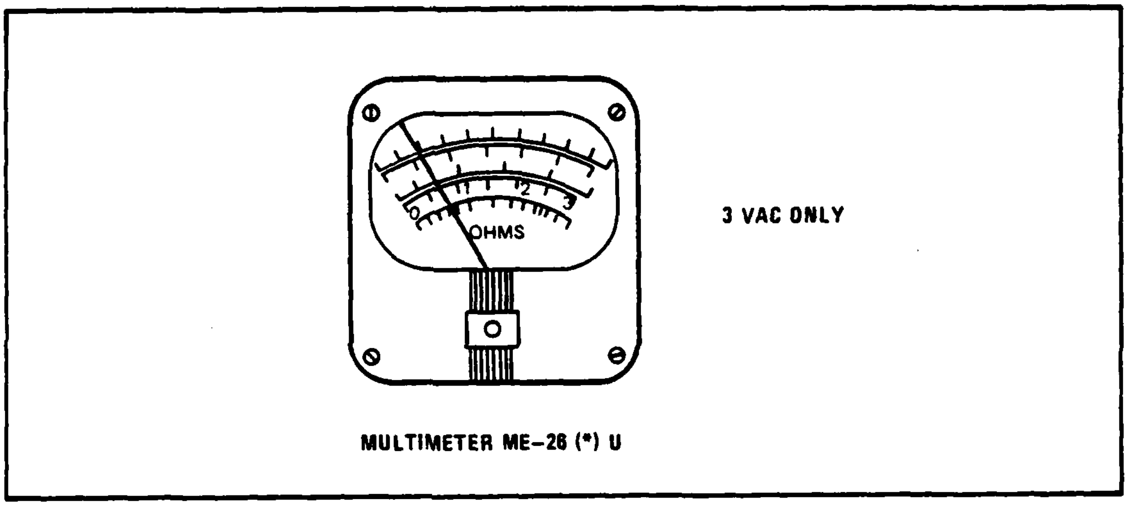


Figure 15-2

V. No measurement item.

Figure 2-2 (cont.)

VI. Which test point in figure 15-3 is the emitter of transistor Q13? Use schematic (figure 15-4) to help answer this question.

A. test point A

B. test point B

C. test point C

D. test point D

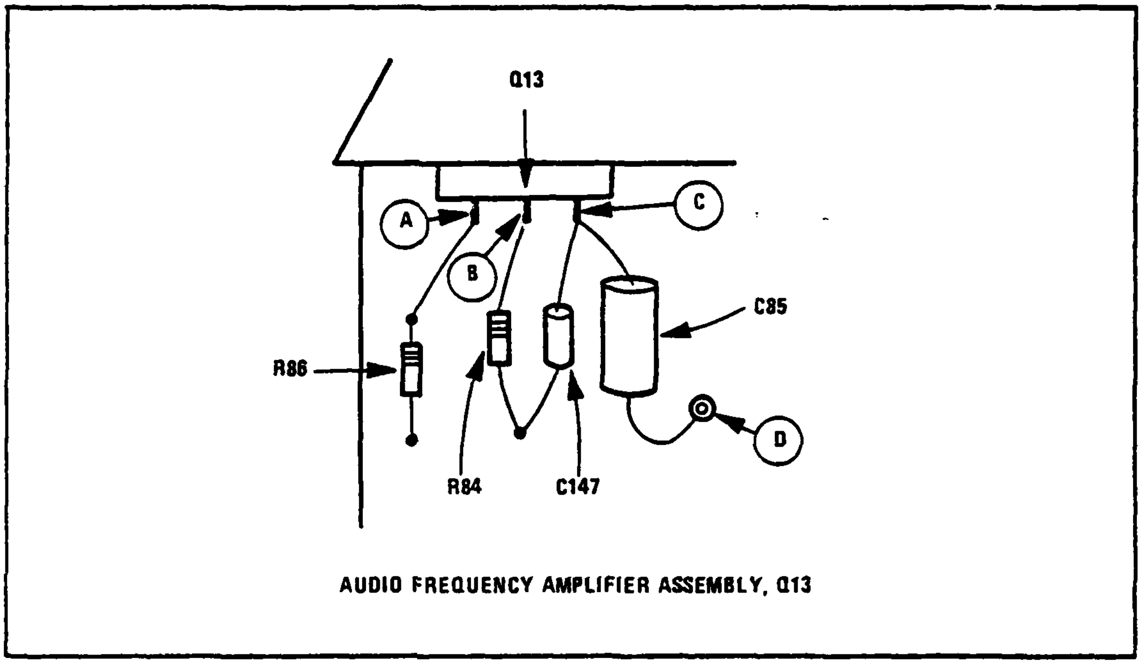


Figure 15-3

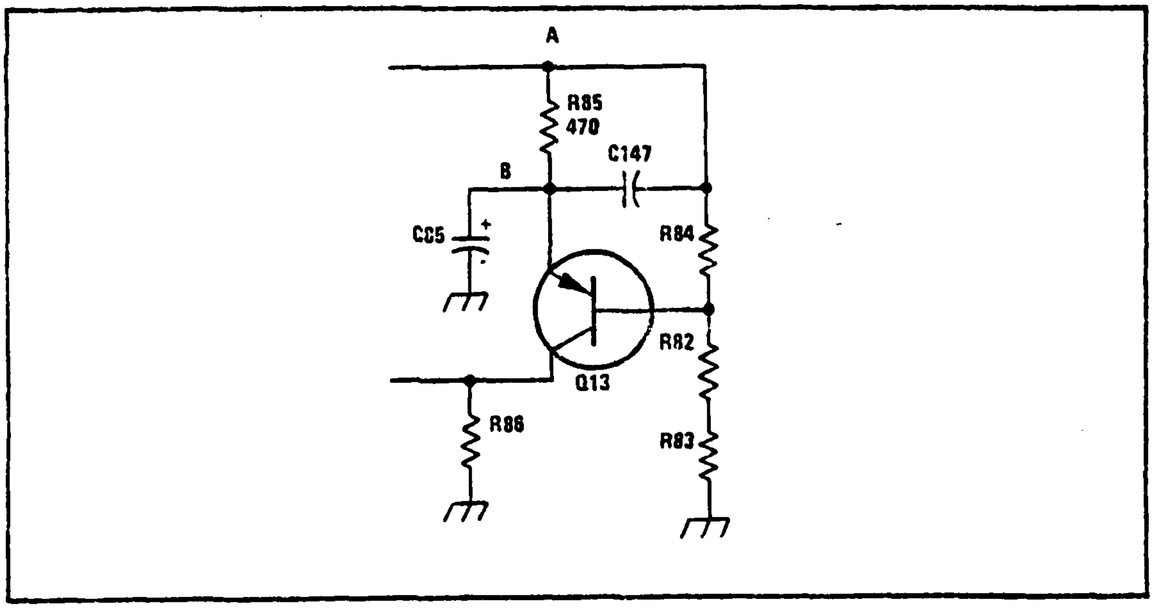


Figure 15-4

Figure 2-2 (cont.)

VII. During performance of step 3-7g(9) of the synchronization test, you read 333° on the angle position indicator. What is your next step?

A. perform step 3-7h(1)

B. synchronize the ASN-43 system

C. measure voltage at test points

D. measure resistance at test points

VIII. You are setting the MK-733 controls required for the Control Unit Test. Which of the following switch configurations is correct ?

Figure 2-2 (cont.)

A.

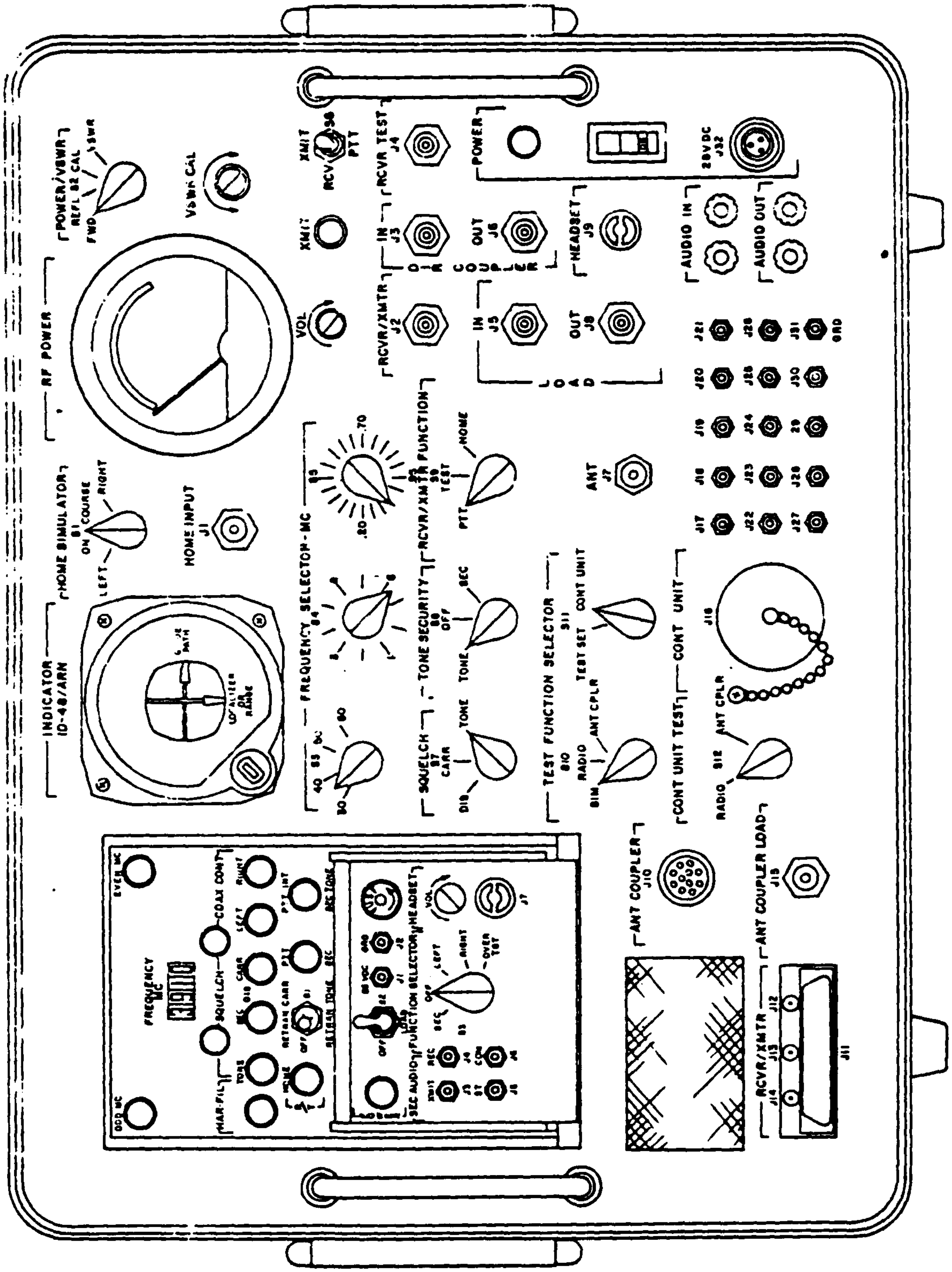


Figure 2-2 (cont.)

B.

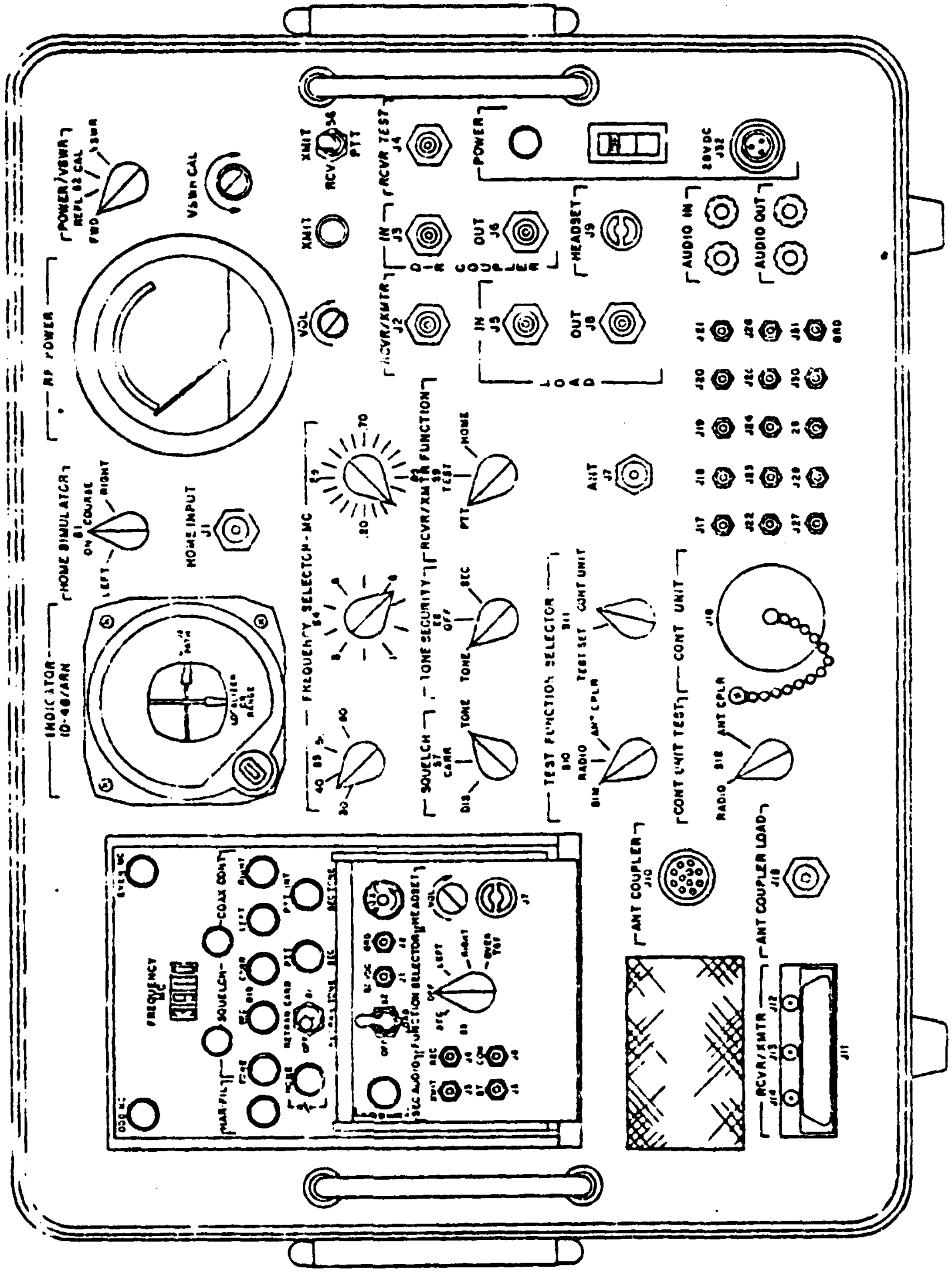


Figure 2-2 (cont.)

C.

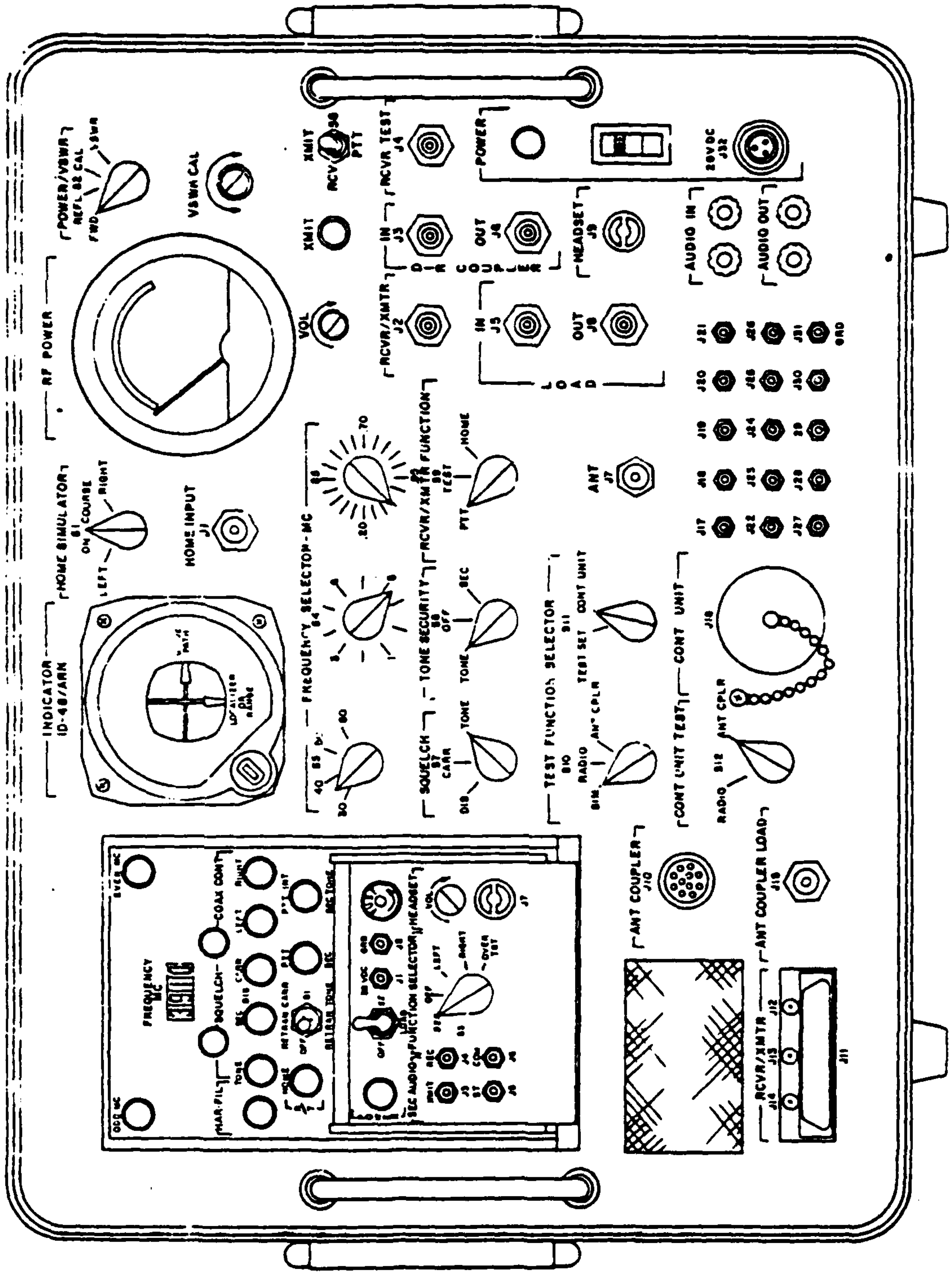
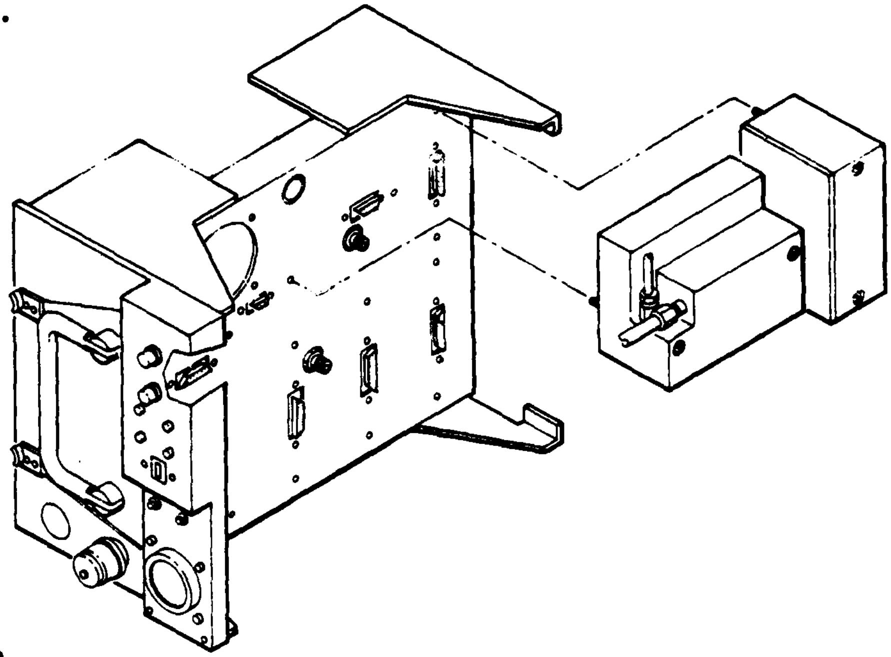


Figure 2-2 (cont.)

IX. You are installing receiver 1RE1. How should you position receiver 1RE1 with respect to the chassis assembly?

A.



B.

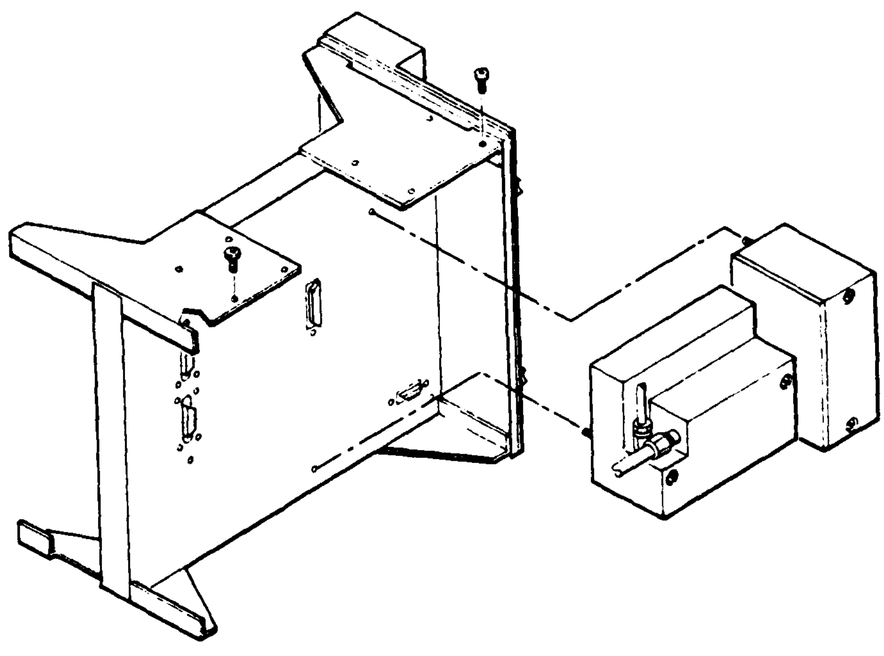
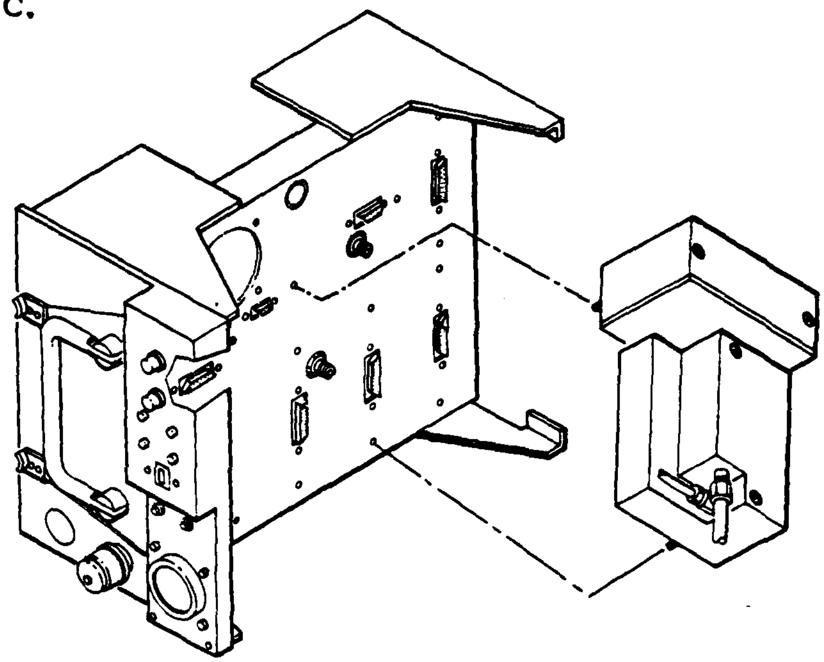


Figure 2-2 (cont.)

C.



X. What precaution should you take to prevent the RF power output of the radio set from damaging test equipment?

A. insert a 20 dB power attenuator between the radio set and the test equipment

B. always press the front panel TONE button with the RADIO TEST selector switch in position 6

C. ensure that the power source does not exceed 115 Vac

D. insert an RF coupler between the power amplifier Q2 and the low pass filter L4-L13

Figure 2-2 (cont.)

fairness, release of the actual test contents must be controlled by the Signal School and TRADOC. Table 2-13 shows the distribution of the correct alternative letter codes for the SQT written components.

Task 4 - Evaluate Specificity of Required Task Analysis Documentation

Develop interview protocol--An interview protocol was developed to examine aspects of the task analysis documentation, including degree of specificity and detail required, and the adequacy of SQTs developed from the task analysis. The interview protocol was designed as a stimulus for discussion in these areas and to guide rather than inhibit discussion. Consequently, the questions were presented in an open ended format.

The interview questions covered two main areas: 1) the position of the individual within the organization and his particular responsibilities. Included were questions on the individual's staff, resource constraints, student involvement (if any), regulation of tasks by doctrine, and type of documents used and produced; and 2) the individual's use and/or view of potential for task analysis methodologies such as the Generalizable Job Proficiency Matrix (GJPM). This area included questions on possible use of the GJPM, its resultant effect, and its relationship to governing doctrine. Included also were questions on the required level of specificity for the GJPM to show maximal usefulness.

The interviewer was supplied with a partially coded version of the protocol, designed so that he could enter information into particular response categories quickly, and also record

TABLE 2-13. RESPONSE CODE DISTRIBUTION.

Correct Alternative Code

SQT	MOS	# UNITS	A	B	C	D	E	TOTAL
2	35L	9	13	12	12	10	4	51
	35M	32	30	41	30	31	13	145
	35R	18	20	32	33	35	5	125
	TOTAL	59	63	85	75	76	22	321
3	35L	10	10	12	15	9	4	50
	35M	13	12	21	18	11	5	67
	35R	9	14	19	10	15	3	61
	TOTAL	32	36	52	43	35	12	178
	GRAND TOTAL	91	99	137	118	111	34	499
	%		20	27	24	22	7*	100

* A total of 106 of 499 measurement items had 5 alternatives.

any elaboration (and/or relevant digression) that may occur during the course of the interview.

Appendix C gives the complete protocols for the interviewer and interviewee.

Conduct interviews--Interviews were conducted with personnel at the U.S. Army Signal School at Ft. Gordon.

Personnel interviewed represented three organizations:

- Avionics Task Analysis Division
- Avionics (Training) Design and Development Division
- Instructors for 35B, 35L, 35R, and 35K MOSs.

Personnel from the Avionics Task Analysis Division and instructors were interviewed individually. Personnel from the Design and Development Division participated in a large group discussion with the interviewers. The results of the interviews are summarized below:

SQT development--Written portions of the SQTs for MOSs 35R, 35L, and 35M were judged very positively by all individuals who responded. Areas viewed particularly favorably include:

- The use of tech manual abstracts for a portion of the questions. These questions required that the examinee find the relevant information in the abstract for answering the question. This method was viewed positively since it was more representative of the type of actions that the soldier would actually do in the field.

- The use of graphics depicting actual equipment configurations.
- The range and representativeness of the questions.
- Coverage of different generations of equipment (e.g., obsolete but still used tube type equipment to latest generation equipment).
- Representation of some of the skills necessary in troubleshooting.

Negative comments on the SQTs were minimal. The question was raised about the reading level of the SQT items. TRADOC demands that SQTs be written at a 7th grade reading level. However, the use of actual technical manual extracts in the questions may to some degree violate this principle, since technical manuals are often written at a higher reading level. This problem was viewed more as indicative of the variation in technical manuals than of the SQT use of technical manual extracts, and it was suggested that the reading level of technical manuals be subjected to greater standardization for future equipment.

Generalizable Job Proficiency Matrix--The Generalizable Job Proficiency Matrix (GJPM) was in general judged to be a useful conceptual device for the task analysis used to define MOS related skills. Four areas of possible use of the GJPM were proposed by the interviewer, and were discussed with the partcipants. These were:

- SQT development and skill evaluation
- Training requirements
- Training media requirements
- MOS management.

The use of the GJPM for constructing the written portion of the SQTs for MOSs 35L, 35M, and 35R was viewed very favorably. However, it was pointed out that the GJPM could not be used in the development of all SQT; those at higher skill levels, especially those which are not easily proceduralized such as a supervisory MOS, do not lend themselves as well to GJPM analysis, and therefore the GJPM is less useful in such SQT developmental activities.

The topics of what was to be trained, and the methods to go about training were discussed together. The GJPM was viewed as a useful device in defining training requirements due to its orientation to actual task performance rather than abstract knowledge. Consequently, the GJPM would be most relevant in the Design and Development Division. The suggestion by the interviewer that the GJPM could be used to define training device requirements and aid in device design considerations was viewed with interest tempered by limited familiarity with maintenance training simulators in general. However, the need was expressed for devices to aid in the hands-on portion of the SQTs, especially in fault isolation.

A common statement was made that the MOS system must be oriented to better match the specific needs of the field, the assignment of skill levels to job requirements, and the accommodation of new generation equipment to MOS creation or allocation. In general, the GJPM was viewed as a potentially useful device for MOS management, both within an MOS and across MOSs. It was decided that the GJPM would be a useful tool for documenting the necessity for MOS examination, especially since changes are typically proposed with less formal documentation.

Specificity of the GJPM--A major issue concerns the degree of task analysis specificity required in the GJPM for it to be a useful analysis device. Since the GJPM is most useful in discerning commonalities and differences in tasks at the generic level, the question becomes how generic are those tasks; that is, where along a specificity-genericness dimension would the task analysis be most useful.

The consensus in the specificity issue during the interviews was that the level of the task analysis represented in the GJPM was sufficient for the development of the particular SQTs addressed, but that the specificity may need to be altered for other applications. The level of specificity in the GJPM was viewed particularly favorably since it pointed out the degree to which technical manuals differed in the description of the same tasks; the GJPM could therefore serve as a device to document the necessity for standardization of technical information. The necessity for subject matter experts (SMEs) at all stages of GJPM development, both from the Signal School and from the contractor, was pointed out very strongly, to monitor appropriateness of task selection and specficity, both from a technical standpoint and from the standpoint of the purpose for which the particular GJPM was to be used.

The present contract specified that the task by element matrices developed for the three Army avionics MOSs would be used to develop scorable units for the written component of the three SQTs. This requirement had a major impact on the development of the matrix concept. The purpose for which the matrix would be used, the available task analysis documentation, the Soldier's Manual and technical manuals, and the MOS structure all served to impose constraints or boundary conditions on the structure, form, and level of specificity of the analysis.

The approach followed in defining behavioral elements is logical, straightforward, easily interpretable, and easily applied. Yet it must be stressed that the concept and definition of a behavioral element must always be a function of both the technical data available and the ultimate purpose to which the matrix will be applied. For example, a person concerned with MOS reorganization would use different behavioral elements from one preparing a functional specification. In the first case, behavioral elements for the matrix may be subtasks of the critical tasks in the MOS (e.g., critical task - adjust RT-XXX - may be broken down into the following elements--adjust gain, adjust squelch, adjust carrier signal, etc.) whereas someone concerned with defining a functional specification for a training simulation facility would be concerned with more discrete behaviors (e.g., monitor test set meter, push reset button in, turn homing knob to 270°). Other potential developers and users of the GJPM concept must always adjust their use of the concept based on their specific requirements.

SECTION III

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The objectives of this study were to develop task by behavioral element matrices (Generalizable Job Proficiency Matrices (GJPM) for three avionics MOSs 35L, 35M, and 35R) and to use the task commonality to develop written components of SQTs for those MOSs. The following three major conclusions can be drawn from the performance of the study.

1. The Generalizable Job Proficiency Matrix was a significant aid in developing written SQTs that were representative and exhaustive of the tasks necessary for adequate performance within the MOS. Specifically, the GJPM allowed (and demanded) the analysis of the MOS such that the task results were at the behavioral level most useful for the development of scorable units. Moreover, the use of the standard Soldier's and technical manuals for the source of the tasks helped to assure that the SQTs would conform to acceptable training standards and formats. The use of extracts and graphics from the technical manuals and Soldier's Manuals as part of the SQT question stems added further to the representation in the SQT of the type of tasks that the soldier would be performing in the field.

2. The process of constructing the GJPM itself led to greater understanding of the skills and responsibilities of each MOS. Constructing the GJPM demanded an in depth analysis of the requirements of each MOS, including the types of equipment used, the particular actions to be performed, and the necessary knowledge base to perform adequately in the MOS. However, the use of subject matter experts (SMEs) in the process was required due to the judgments that were necessary on the nature of equipment, actions, and knowledge commonalities and differences. The GJPM served the purpose of consensual validation for the developers to the extent that it provided in matrix form a recognizable description of major MOS elements, but also pointed out areas of commonality that were not previously apparent, and, conversely, areas of difference where commonality was assumed. The GJPM therefore served a large function as a documentation device describing in an objective manner MOS elements that were hitherto treated in a more informal manner.

3. The specificity of the task analysis in the GJPM was appropriate for SQT development, but may be altered as the use for which the GJPM is intended varies. A major question in the development of a "generic task" matrix is the level at which tasks are judged similar. Greater similarity judgments are appropriate when the goal is to compare MOSs than when the goal is to define scorable units within an MOS. The process of deciding the level of specificity also will lead to greater understanding of a given MOS and its relationship to other MOSs.

Recommendations

The success of the GJPM concept in the development of SQTs for three avionics MOSs suggests further application of the concept. Specifically, these applications may include:

1. Extension of the GJPM to other MOSs, both with the objective of further SQT development and as a general analysis tool. Ft. Gordon is responsible for the training and evaluation of 54 MOSs. The use of the GJPM (with appropriate SMEs) to analyze these MOSs would allow determination of commonalities that could be exploited in both training and SQT development. Computerization of the GJPM concept would allow ready analysis, and revision of MOS requirements as new generation equipment is added and obsolete equipment deleted.

2. The GJPM concept can be used for determining training requirements and for the design of training media and devices to meet the training requirements. A useful addition to the training of maintenance functions would be bench-type simulated actual equipment trainers with high structured fidelity, but with functional capability to meet major training requirements. The capabilities of the media and training devices are determined using the GJPM to identify major training requirements; the media are then chosen and the training devices are designed to meet the major training requirements. The use of the GJPM in conjunction with specially designed training equipment could also serve as the medium for the hands-on component of the SQTs. Such training equipment

has the advantage over actual equipment of greater fault insertion for demonstration of troubleshooting skills. Devices designed using generic GJPM elements may also serve training across MOSs.

3. The GJPM can be used as a method for the analysis and documentation of MOS management. The MOS system is faced with the accumulation of new technology, lower skill levels of students, and meeting the needs of the field. The GJPM can describe the task requirements of these sources as well as the task elements present in existing MOSs either to lead to the best match to existing MOSs, or to support the need for MOS revision in the creation of new MOSs. The GJPM can serve as a standardized documentation device supporting recommendations generally relevant to MOSs.

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APPENDIX A

GENERALIZABLE TROUBLESHOOTING GUIDE

Honeywell

79SRCM-5

May 1979

GENERALIZABLE TROUBLESHOOTING GUIDE

SYSTEMS & RESEARCH CENTER
2600 RIDGWAY PARKWAY
MINNEAPOLIS, MINNESOTA 55413

PRINTED IN USA

TROUBLESHOOTING

INTRODUCTION

This guide is written to help you repair and maintain avionics equipment in the field. It is not intended to be a repair manual for every piece of electronic equipment you will see in the field. It is intended to aid you and to answer, in general, the question: "What do I do next?". This guide gives a simple, easy to follow, step-by-step method to find and repair faulty equipment.

BEFORE YOU START

To do a job well, you must have the right tools. Most beginning technicians know that screwdrivers, wrenches, pliers, and soldering irons are tools used to repair electronic equipment. There are some other tools that the technician uses that aren't as obvious. You need to know how to use these tools before starting to work on any piece of avionics equipment. These tools are:

Knowledge of Electronic Fundamentals: This does not mean detailed theory and mathematics of electronics. It means understanding how the basic circuit parts (resistors, capacitors, transistors, etc.) work and what happens when they don't work.

Knowledge of the Equipment: Most equipment can be broken down into a few basic circuits (power supply, amplifier, oscillator, etc.). Knowledge of the equipment means knowing how these basic circuits are put together to make the equipment you're working on. It also means knowing what equipment should do in all modes of operation and knowing when it's not being done. Block diagrams and functional theory of operation give you this information.

Knowledge of Test Equipment: Most avionics equipment needs general test equipment for troubleshooting. This includes multimeters, oscilloscopes, signal generators, etc.. You will probably run into many different types and models of test equipment even though their function is the same. You may know how to use one type of oscilloscope but have an entirely different one in your shop. If this happens, the best thing you can do is read the operation manual for that oscilloscope or ask a co-worker who is familiar with the equipment to show you how to use it.

Some avionics equipment also has special testers which are designed only for that unit. The technical manuals will tell you how to hook up and use these special testers. The technical manuals also tell you how to make readings and what to do if they are not correct.

The Technical Manual: The technical manual is the most important tool you have. It contains theory of operation, operation, testing procedures, schematics, block diagrams, charts, and other information you need. You should be familiar with where everything is in the technical manual and know how to use its information.

Logical Troubleshooting Method: The logical troubleshooting method is what this guide is all about. If you have all of the tools mentioned, then this is the easy part. The method breaks down into six easy steps. When you follow the method using all of these tools, the troubleshooting job is done.

The Technician: Nothing fixes itself. A skilled technician is always needed to find and repair a piece of equipment that is not working right. The soldier who uses these tools, thinks clearly, and makes the right decisions will repair the equipment every time. Anyone else is just lucky.

TROUBLESHOOTING STEPS

Once you have all the tools you need, you are ready to tackle a troubleshooting problem. The logical troubleshooting method includes these six steps:

1. Symptom Recognition
2. Performance Check/Bench Check
3. Listing Probable Faulty Functions
4. Finding the Faulty Function
5. Finding the Faulty Circuit
6. Repairing/Replacing Faulty Component(s)

Step 1. Symptom Recognition: Symptom recognition means finding or realizing that a piece of equipment or an equipment system is not doing the job it is supposed to do. Most of the time this step is performed by the pilot or operator using the equipment. This means that when you get a piece of equipment you will already know that something is wrong with it. Finding out what is wrong with it is your job. Don't count on getting very much information from the pilot or operator. They are not trained in your field and can't be expected to know what is wrong. Most of the time you will be given information like: "VHF doesn't work" or "warning light on."

But there are some problems that aren't so easy to see. These are normally called "degraded performance" problems. They can include problems like a radio transmitter that has lost some of its range or has a decrease in signal/noise ratio. You should notice these degraded performance problems during routine alignment/adjustment or bench test of the equipment. You should take extra care to find degraded performance problems.

Step 2. Performance Test/Bench Check: In this step you must pin down exactly what the equipment is or is not doing correctly. In some cases you can do this step in the aircraft and in others you must do it on the bench.

This is where you must start using your tools. You must know how to operate the equipment and know what it is supposed to do.

You should power up the equipment and operate it in all possible modes. All frequency ranges, control settings, positions, etc. should be observed. Take careful notes on switch settings and meter readings and any other visual information you can get. This information will be of great value to you later.

You should make a visual inspection at this point. Look for burned or broken parts, broken wires, loose cards or connections. If the equipment has plug-in cards, reseating them will often solve the problem. Cards are often shaken loose if the unit gets a lot of vibration when it's operating.

You may also find out at this point that there is no problem with the unit or that a simple adjustment cures the problem. If you find no problem, this usually indicates an operator error. You should point this out to the operator to prevent it from happening again. Another possibility is that the unit fails only under certain conditions. For example, the cooling air in the aircraft may be blocked, causing the equipment to overheat after an hour in flight. These failures are hard to find because the equipment will usually bench-check O.K. Repeated writeups on a piece of equipment that bench-checks O.K. should lead you to a problem like this.

If the unit or system has built-in-test equipment (BITE), you can get good information from using this function also.

When you're checking the unit out by trying all the modes and switch settings, make sure you only change one setting at a time. This way, you won't get a wrong reading or miss something.

Step 3. Listing Probable Faulty Functions: Now that you know exactly what the unit is or is not doing, you must figure out which functions of the equipment could cause this problem. To find these faulty functions, you need another tool. This tool is understanding how the equipment works. You will also need a functional block diagram from the technical manual.

You have to start doing some thinking now. Use your knowledge of the equipment and the information you gathered in the last step. Now you should decide which function(s) of the equipment could be faulty. Sometimes this is a very simple job. For example, a receiver has gone dead and during Step 2 you notice that the meter on the front panel that monitors the power to the system reads zero. From this information, you should go to the power supply. Most of the time, however, there will be two or more functional units in the equipment that could be faulty. Some units are more likely to be faulty than others, but don't make the mistake of not considering a probable fault just because you've never seen it happen before. If your shop keeps maintenance records (and they should), refer to the records on that unit. Sometimes you will find a probable fault that you didn't think of. If your shop doesn't keep records, then you should keep a detailed notebook of everything you repair. Over a period of time, this notebook can become a very valuable tool.

You may find it easier in some cases to list what isn't a probable fault. For example, you have a radio transmitter that provides a good, clean carrier signal but no modulation. You would not need to check the RF oscillator, RF power amp, or power supplies to these sections. This leaves you with the microphone circuit, audio section, and modulator section as probable faults.

The technical manual may also provide some information in the form of a "sectionalization chart." These charts (see Figure 1) basically perform Steps 3 and 4 for you during the bench-check. These charts won't always be 100 percent correct, but they will lead you in the right direction and save you some time.

In any event, once you find out which sections or functions have probable faults, you can go to Step 4.

Item	Symptom	Probable cause	Sectionalization procedure
1	Test power supply draws excessive current when 28 volts is applied to vhf navigation set. *Note.* When test power supply is used, excessive current drain will be indicated by a high (7 amperes or more) dc ammeter reading or by tripping of the test power supply circuit breaker.	Defective test power supply, vhf navigation receiver, converter, vhf control unit, or rack.	*a.* Disconnect the test power source from the vhf navigation receiver; apply low-voltage input power again. If current drain is reduced, replace test power supply; if not, perform *b* below. *b.* Reconnect the test power supply supply to the vhf navigation receiver and disconnect the converter from the rack. Apply low-voltage input power again. If current drain is reduced, replace the converter; if not, perform *c* below. *c.* Reconnect the converter to the rack and disconnect the vhf navigation receiver from the rack. Apply low voltage again. If current drain is reduced, replace the vhf navigation receiver; if not, perform *d* below. *d.* Reconnect the vhf navigation receiver to the rack and disconnect the cable at connector J2 of the vhf navigation receiver. Apply low-voltage power again. If cu[illegible]nt drain is reduced, replac[illegible] vhf navigation control unit; if not replace the rack.

Figure 1. Sectionalization Chart

Step 4. Finding the Faulty Function: Now you are faced with the problem of finding the faulty function or section. This is sometimes called sectionalizing. If during Step 3 you find that only one function or section has a probable fault, then you would go to Step 5.

Up to this point, you have not used any test equipment other than what has been built into the equipment itself. Now you will have to add another tool, the knowledge of how to use test equipment, to continue the troubleshooting job. The test equipment is used to find out which function is faulty. You will again need the equipment functional block diagram. A system block diagram is shown in Figure 2. Now you will have to do more logical thinking. If you just dive in and make random measurements in the hope of finding a bad signal, you will be very lucky to fix anything.

Choosing where to start testing to find the faulty function depends on several things. One of the most important things is to find the function that will give you the most information. In other words, you should ask the question, "Which signal should I check in order to lower the number of probable faults?". For example, you have a receiver with no output. A functional block diagram of the receiver is shown in Figure 3.

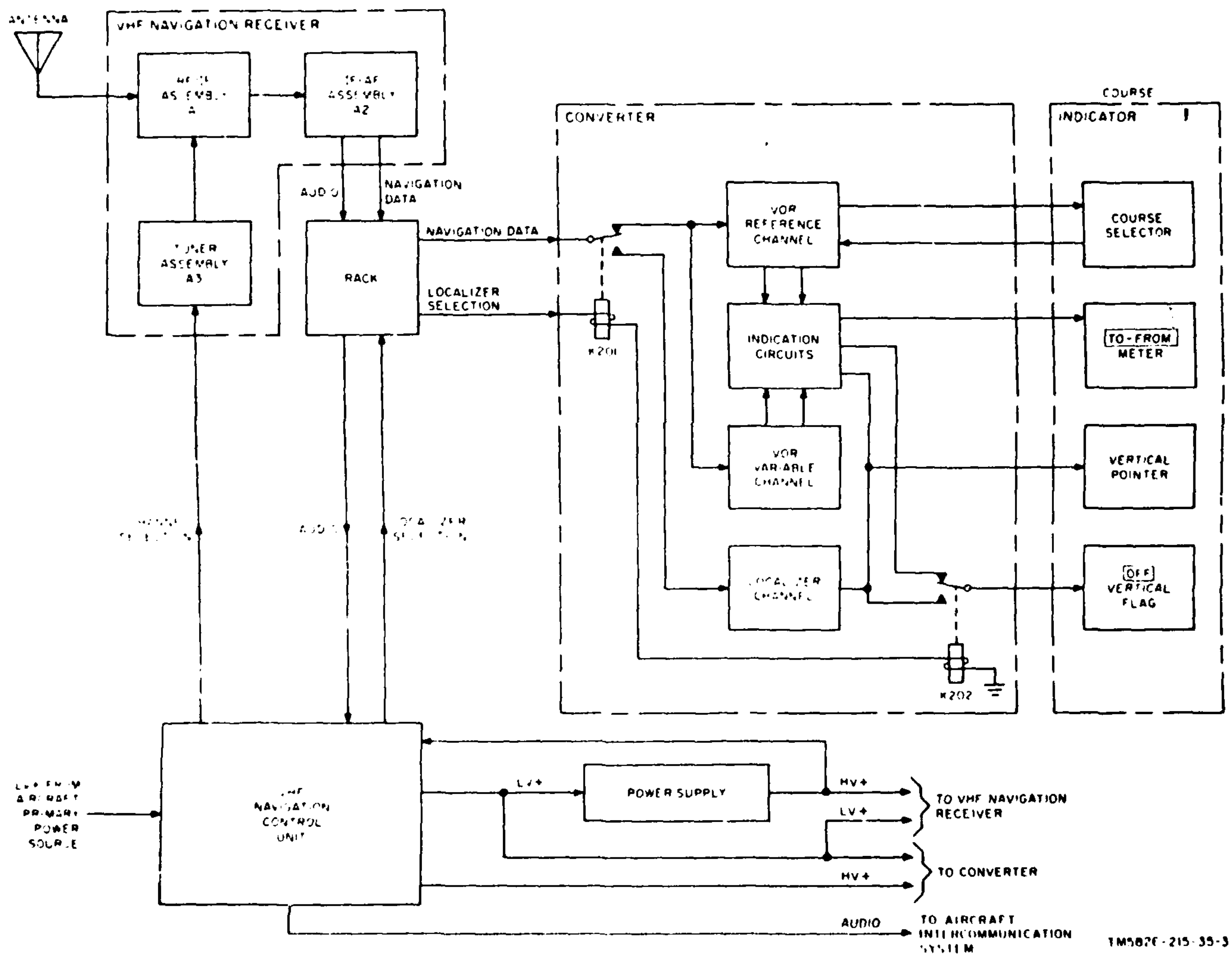

Figure 2. System Functional Block Diagram

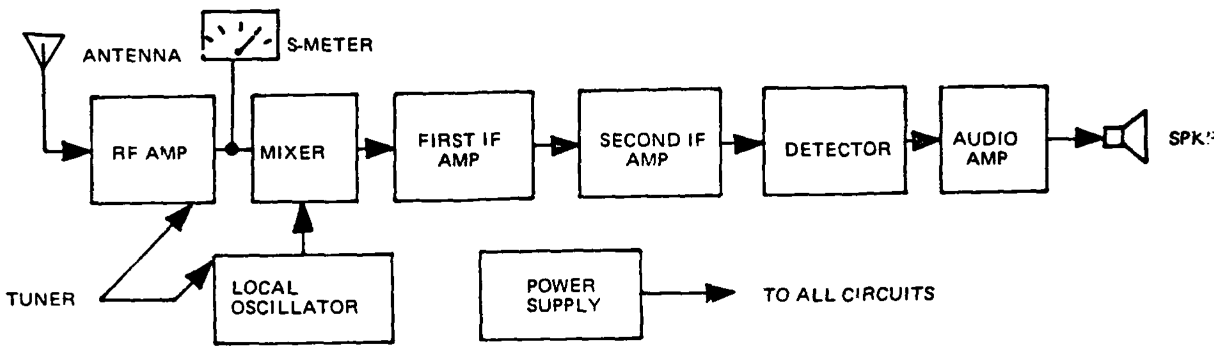

Figure 3. Receiver Block Diagram

The "S-Meter" in Figure 3 shows a strong incoming signal and since it is at the output of the RF amplifier you can be sure that the antenna and RF amp are O.K. It is also likely that the power supply is O.K. unless all of the circuits are at different voltages. This leaves the local oscillator, mixer, first IF amp, second IF amp, detector, audio amp, and speaker. Starting at the speaker and working backwards, or starting at the local oscillator and working forward, will work. But it will take you a lot of time if the fault is at the other end. Checking the signals between the first and second IF amp will give you a lot more information. If the signals are good, then you know that the first IF amp, mixer, and local oscillator are O.K. If the signals are bad, then you know that the second IF, detector, and audio amp/ speaker are O.K. With one measurement (or set of measurements) you have eliminated half of the probable faults. Some technicians call this the halving technique.

There are some things that may make you check somewhere else first. These include available test points, ease of access, etc. The technical manual should include a list of test points and what signals should be present.

An important point to remember is that you will normally be testing the output of a circuit. Just because the output is bad doesn't mean that the circuit you're testing is bad. An amplifier's output will always be wrong if its' input is bad! Don't jump to conclusions. Work carefully and think about every step. It will save you a lot of time and confusion later.

One other possibility for finding the faulty function is to use a trouble-shooting chart like the one shown in Figure 4. These charts are very general and are designed to help you find the fault most of the time. They should be used to help you find the faulty function but should not be taken as gospel.

Step 5. Finding the Faulty Circuit: Once you have found the faulty function, you must find the circuit that is causing the problem. To do this, you will repeat Steps 3 and 4.

Here you must consider these possibilities:

1. The faulty function may have only one circuit. In this case you can go directly to Step 6.

2. The faulty function may have only one signal path. In this case the halving technique described in Step 4 works quite well.

3. The faulty function may have many signals and signal paths and only one or two of them may be faulty. This case will be described to you more later.

Before you can start troubleshooting the function, you will need detailed block diagrams of the function (a converter block diagram is shown in Figure 5) or you will need the schematic diagram. The schematic diagram is sometimes better because it usually shows the location and expected signals of the circuit test points.

Again, if there is only one signal path you can start at a convenient middle point (use the halving technique) and work from there. Be careful to select the proper test equipment for the signal you're measuring. Using a low-impedance VOM on a high-impedance circuit is likely to give you some interesting, but wrong, results. If the function unit must be separated from the rest of the system so it can be tested, you will usually need a bench tester or a signal generator, power supply, etc. to do these tests. The technical manual will normally list the equipment and signal connections/levels you need to do these tests.

Item	Indication	Probable trouble	Procedure
1	OFF vertical flag on the course indicator is visible at all times and the TO-FROM meter on the course indicator is always at neutral, even though audio can be heard on both VOR and localizer channels.	Defective tube filament in VOR reference channel, VOR variable channel, or flag emphasizer stage V207.	Visually check tubes (fig. 34) to see that all light.
		Capacitor C219B (fig. 35) shorted to ground.	Check for short circuit (para 68c).
2	OFF vertical flag on the course indicator is visible and the TO-FROM meter on the course indicator is at neutral during localizer, but not during VOR operation.	Defective localizer channel.	Check tube V206 (fig. 34) by substitution. Make signal-substitution tests on localizer channel (para 71a). Make voltage and resistance measurements on localizer stages (fig. 37).
		Defective relay K201 (fig. 49) or K202.	Check operation of relays K201 and K202 (para 97). Check coil resistance measurement for relays K201 and K202 (para 73).
3	OFF vertical flag on the course indicator is visible and the TO-FROM meter on the course indicator is at neutral during VOR, but not during localizer operation.	Defective VOR variable channel.	Check tubes V205 (fig. 37) and V201 by substitution. Make signal-substitution tests on VOR variable channel (para 71c). Make voltage and resistance measurements on VOR variable channel stages (fig. 37).
		Defective VOR reference channel.	Check tubes V201 (fig. 37), V202, V203, V204, and V205 by substitution. Make signal-substitution tests on VOR reference channel (para 71b). Make voltage and resistance measurements of VOR reference channel stages (fig. 37).
		Defective VOR flag emphasizer stage V207.	Check tube V207 (fig. 37) by substitution. Make voltage and resistance measurements of VOR flag emphasizer stage V207 (fig. 37).
		Defective transformer T201 or T202.	Check resistance of transformers T201 and T202 windings (para 73).
4	TO-FROM meter on the course indicator does not deflect, although vertical pointer on the course indicator deflects and OFF vertical flag on the course indicator is out of sight.	Defective crystal diode CR205 or CR206.	Measure front-to-back resistance of crystal diodes CR205 (fig. 35) and CR206; ratio of resistance readings should be 10,000 to 1 or greater.
		Defe[illegible]e resistor R235, R236, or R253.	Check resistance of resistors R235 (fig. 35), R236, and R253.
		Defective capacitor C235.	Check capacitor C235 (fig. 35) for shorted condition.
5	OFF vertical flag on the course indicator is visible during VOR operation, but not during localizer operation, although the TO-FROM meter deflects and VOR signal strength is reliable enough for vhf navigation set operation.	VOR FLAG control R268 out of alignment.	Check alignment of VOR FLAG control R268 (para 107).
		Defective crystal diode CR207 or CR208.	Measure front-to-back resistance of crystal diodes CR207 (fig. 35) and CR208. Resistance ratio should be 10,000 to 1 or greater.
		Defective resistor R237, R238, R239, or R240.	Check resistance of resistors R237 (fig. 35), R238, R239 (fig. 36), and R240 (fig. 35).
6	Vertical pointer on the course indicator does not indicate correctly and the TO-FROM meter on the course indicator operates erratically (deflects correctly part of the time and incorrectly other times) during VOR operation.	VOR reference channel and/or course indication circuits out of alignment.	Check alignment of VOR reference channel and course indication circuits (para 107 through 110).
7	Vertical pointer on the course indicator does not indicate correctly during localizer operation.	Localizer channel and/or course indication circuits out of alignment.	Check alignment of localizer channel and course indication circuits (para 108 through 111).

Figure 4. Troubleshooting Chart

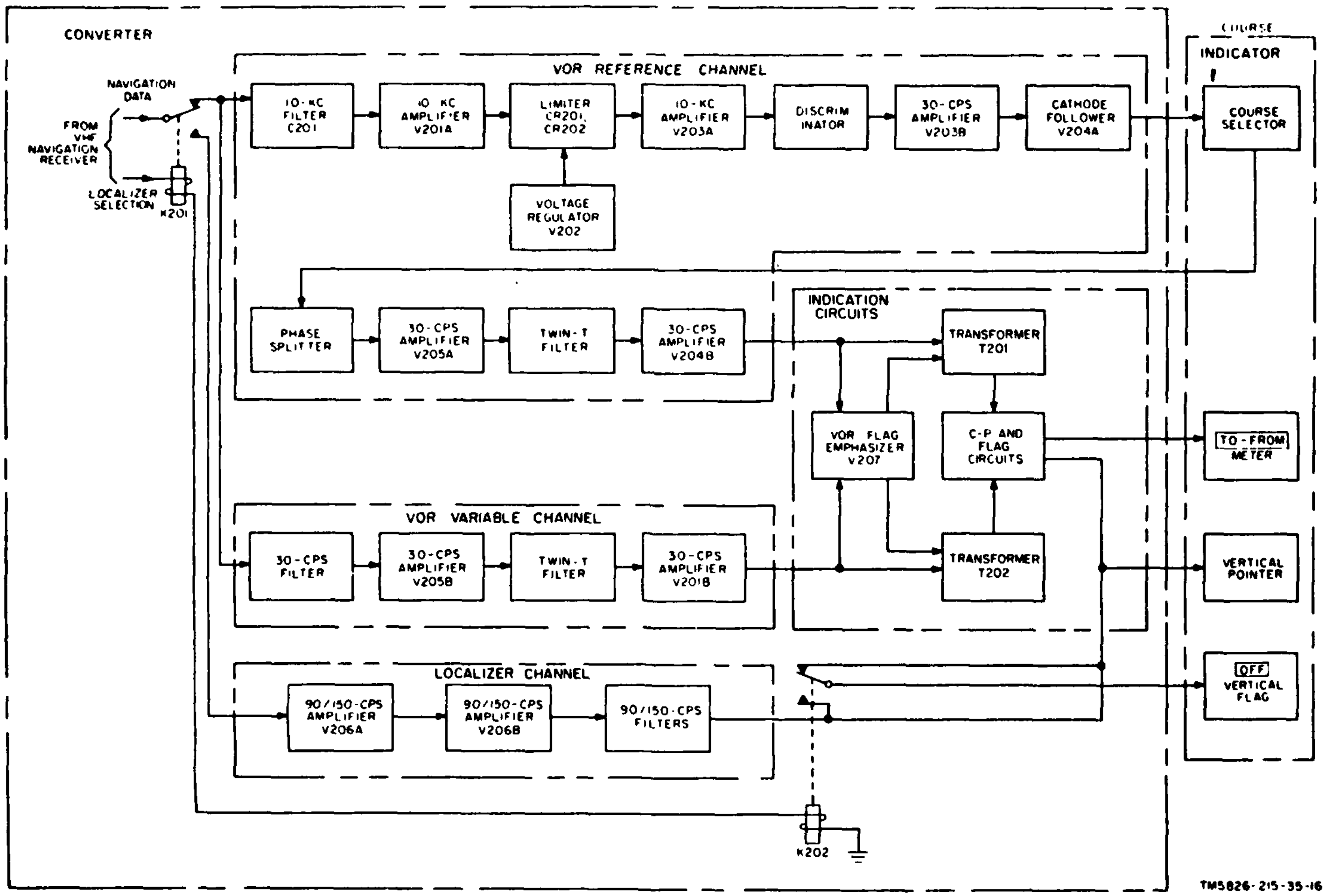

Figure 5. Converter Block Diagram

If there is more than one signal or signal path, you will again have to do some thinking. You have to find out which circuits could cause the problem and eliminate the others. Consider all circuits that generate, modify or control the bad signal. For example, if you have a triangular wave without a linear slope you might consider the shaping network. Look back at your results from Step 2. If there was a control that caused the problem in the unit, the circuit it is connected to is a likely source of the problem. Once you find the probable faulty circuits, use the halving technique to find the one that's causing the problem.

Step 6. Repairing/Replacing the Faulty Component(s): Once you have found the faulty circuit, you will have to find the specific component or components that failed. You will need the schematic diagram and component layout drawing to do this step.

Since almost all circuits have an active component (for example, tubes, transistors, integrated circuits) and most faults involve an active component, this part should be checked first. Tubes and plug-in transistors can be checked on the proper tester out-of-circuit. Soldered-in transistors and integrated circuits should be checked in-circuit. If you find a bad active component, don't forget that many transistors or IC failures are caused by the failure of other components (shorted loads, shorted coupling capacitors, etc.).

The technical manual usually has a resistance chart that will help you a lot in finding faulty components.

Once you have found the faulty component(s), you must replace them with the proper new part. Be very careful when using a soldering iron to remove/replace components. You can do more harm than good if you get a hot soldering iron too close to a wire bundle or a printed circuit board.

AFTER YOU HAVE REPAIRED THE EQUIPMENT

You're not through yet. Now you should do a complete bench check to make sure that your work has indeed repaired the unit. You may have to do a realignment, at least of the repaired function. When the unit checks out, then you're through.

APPENDIX B

TASK BY ELEMENT MATRICES

MOS 35L10 Avionics Communication Repairer Fault Isolate Tasks / Behavioral Elements: Set up, connect & operate: / Task #113-586-	Voltmeter/multimeter	Oscilloscope	Frequency counter/meter	Wattmeter	Signal generator	Spectrum analyzer	Attenuator	Dummy load	Power supply	Headset/microphone	Modulation meter	Frequency comparator	Decade resistor	Test facilities/maintenance kit	Radio test set	Module tester (AN/ARM-87)	Radio interference measuring set	Test set (AN/URM-120)	Test set (TS-1967)	Inspect unit
RT-742/ARC-51BX	X			X	X			X	X	X				X						X
0032	X			X	X			X		X				X						
0033	X				X									X						
0034	X																			
0035				X										X						
0038	X			X	X				X	X				X						
C-6287/ARC-51BX																				
0039	X							X						X						
0105								X						X						X
RT-823/ARC-131	X	X	X	X	X	X			X	X	X			X						
0042	X		X	X	X	X				X	X			X						
0043	X	X	X	X	X	X			X		X			X	X					
C-7088/ARC-131																				
0106	X								X					X						
RT-857/ARC-134	X	X	X	X	X	X	X	X	X					X	X			X		X
0044	X							X	X					X	X					
0045	X	X	X	X	X			X	X					X				X		X
0046	X	X		X	X			X	X					X						
0047	X	X	X	X	X			X	X					X				X		
C-7197/ARC-134																				
0101	X				X		X							X						
RT-1167/ARC-164(V)	X	X	X	X	X		X			X	X	X		X	X					
0102	X	X		X	X		X			X	X	X		X						
0108	X	X	X	X	X					X					X					

MOS 35L10 Avionics Communications Repairer Fault Isolation Tasks

Behavioral Elements

Task #113-586-	Measure:	Voltage	Resistance	Current	Power	Frequency	Continuity	Waveform characteristics	Distortion	Frequency deviation	Mechanical/angular position	Vacuum tube characteristics	Identify:	Symptom	Faulty section	Faulty stage	Faulty part	Interpret:	Fault isolation tables/charts	Schematics/wiring/test point diagrams	Calculate:	Radio set distortion	Gain	S/N, S+N/N ratios	Difference frequency	Percent modulation	Bandwidth
RT-742/ARC-51BX		X	X		X		X					X		X			X		X	X			X	X			
0032		X	X		X		X					X		X			X		X	X							
0033		X	X		X		X							X			X		X				X	X			
0034		X	X											X			X		X	X							
0035														X			X		X								
0038		X	X				X							X			X			X				X			
C-6287/ARC-51BX																											
0039			X				X							X					X								
0105							X							X			X		X								
RT-823/ARC-131		X	X		X	X	X			X				X	X	X	X		X	X							
0042		X	X				X			X				X					X								
0043		X					X							X	X	X	X		X	X							
C-7088/ARC-131																											
0106		X	X		X	X	X							X	X	X	X		X	X							
Rt-857/ARC-134		X	X		X	X	X	X						X	X	X	X		X	X							
0044		X	X				X							X			X										
0045			X											X	X	X	X		X	X							
0046		X	X		X		X	X						X			X		X	X							
0047		X				X	X	X						X			X		X	X							
C-7197/ARC-134																											
0101					X																						
RT-1167/ARC-164(V)		X			X		X			X				X	X		X		X	X							
0102		X			X					X				X					X								
0108							X							X	X		X			X							

Task #113-586-	Remove/replace:	Subassembly/module	Circuit board	Component	Cables, wiring	Monitor:	Audio signal on headset	Test set displays/indicators	UUT displays/indicators	Adjust:	Resistor	Resistor w/oscilloscope	Inductor w/tuning wand	Resistor w/voltmeter	Review symptom list	Repair wiring	Assemble/disassemble UUT	Record test results in digital format	Perform UUT adjustments	Solder/desolder components/wiring	Perform signal substitution	Check part value and operation	Check mechanical operation
RT-742/ARC-51BX		X	X	X	X				X							X	X				X	X	X
0032				X													X				X	X	X
0033			X																		X		
0034																							
0035		X		X																			
0038																							
C-6287/ARC-51BX																							
0039				X																			
0105				X	X				X							X							
RT-823/ARC-131		X	X	X	X		X	X	X							X	X						
0042			X	X			X																
0043		X	X	X	X				X							X	X						
C-7088/ARC-131																							
0106		X						X															
Rt-857/ARC-134		X	X	X	X			X	X		X	X		X	X	X	X	X	X	X		X	
0044																							
0045		X	X	X	X			X							X	X	X						
0046		X		X					X		X	X		X		X		X	X			X	
0047			X	X												X		X	X	X		X	
C-7197/ARC-134																							
0101																							
RT-1167/ARC-164(V)		X	X	X	X		X	X	X						X				X				
0102							X																
0108		X	X	X	X			X	X						X				X				

MOS 35L10 Avionics Communication Repairer Fault Isolation Tasks

Behavioral Elements — Set up, connect & operate:

Task #113-586-	Voltmeter/multimeter	Oscilloscope	Frequency counter/meter	Wattmeter	Signal generator	Spectrum analyzer	Attenuator	Dummy load	Power supply	Headset/microphone	Modulation meter	Frequency comparator	Decade resistor	MK-733/ARC 54 test facilities maintenance kit	Radio test set	Module tester (AN/ARM-87)	Radio interference measuring set	Test set (AN/URM-120)	Test set (TS-1967)	Remove receiver-transmitter dust cover
C-1611D/A1C	X			X	X				X	X					X					
0001	X			X	X				X	X					X					
0141	X				X				X						X					
C-6533/ARC	X				X					X				X						
0002	X				X					X				X						
0004	X				X					X				X						
AN/ARC-114	X	X	X	X	X	X	X			X	X			X						
0003	X	X	X	X	X	X				X	X			X						
0005	X	X	X	X	X		X			X	X			X						
0006	X	X	X	X	X	X				X	X			X						
0010	X			X	X									X						
AN/ARC-115	X	X	X	X	X	X	X			X				X						
0007	X	X	X	X	X					X				X						
0008	X	X	X	X	X	X	X							X						
0009	X	X	X	X	X					X				X						
AN/ARC-116	X	X	X	X	X	X	X					X		X						
0011	X		X	X	X		X					X		X						
0012	X	X	X		X									X						
0013	X		X	X	X		X							X						
0014	X	X		X	X	X	X					X		X						
RT-348/ARC-54	X	X	X	X	X	X	X		X	X	X			X		X	X		X	X
0015					X	X	X		X		X								X	
0016	X		X	X	X									X						
0024	X				X	X	X		X	X	X			X						X
0025	X	X	X		X									X		X	X			
C-3835/ARC-54																				

MOS 35L10 Avionics Communications Repairer Fault Isolation Tasks / Behavioral Elements — Task #113-586-	Measure:	Voltage	Resistance	Current	Power	Frequency	Continuity	Waveform characteristics	Distortion	Frequency deviation	Mechanical/angular position	Vacuum tube characteristics	Identify:	Sympton	Faulty section	Faulty stage	Faulty part	Interpret:	Fault isolation tables/charts	Schematics/wiring/test point diagrams	Calculate:	Radio set distortion	Gain	S/N, S+N/N ratios	Difference frequency	Percent modulation	Bandwidth	Remove/replace:	Subassembly/module	Circuit board	Component	Cables, wiring	Monitor:	Audio signal on headset	Test set displays/indicators	UUT displays/indicators	Adjust:	Resistor	Resistor w/oscilloscope	Inductor w/tuning wand	Resistor w/meter	Review symptom list	Repair wiring	Assemble/disassemble UUT	Record test results in digital format	Perform UUT adjustments	Solder/desolder components/wiring	Perform signal-substitution	Check part value and operation
C-1611D/A1C		X	X		X		X							X			X		X	X											X			X	X	X								X					X
0001		X			X									X																				X		X								X					
0141			X				X										X		X	X											X				X									X					X
C-6533/ARC		X	X				X										X		X	X									X		X	X		X	X	X						X	X	X	X	X			
0002		X	X														X		X	X											X			X								X	X	X	X				
0004		X	X				X										X												X		X	X		X	X	X							X			X			
AN/ARC-114		X	X	X	X	X	X	X	X	X				X			X		X	X				X					X	X	X			X	X	X						X		X	X	X			
0003		X	X	X	X	X		X		X				X					X	X									X	X	X			X	X									X	X	X			
0005		X	X					X									X		X	X				X										X								X		X					
0006		X	X			X	X	X	X								X												X	X				X	X	X										X			
0010		X	X		X												X		X	X																						X		X					
AN/ARC-115		X	X	X	X	X	X	X	X					X			X		X	X									X	X	X			X	X						X	X		X	X	X			
0007		X	X	X	X	X		X						X					X	X									X	X	X			X	X									X	X	X			
0008		X	X	X		X	X	X	X								X												X	X	X			X	X						X								
0009		X	X					X									X		X	X																						X		X					
AN/ARC-116		X	X	X	X	X	X	X	X					X			X		X	X		X	X						X	X	X			X	X	X						X		X	X	X	X		
0011		X	X	X	X	X		X						X			X		X	X														X	X									X	X	X			
0012		X	X	X		X	X	X									X												X	X	X			X	X	X										X			
0013			X														X		X	X			X											X								X		X					
0014		X	X		X			X	X								X		X	X		X	X																			X		X			X		
RT-348/ARC-54		X	X				X	X			X			X	X	X	X		X	X			X						X		X			X	X							X		X		X	X		X
0015														X																				X	X									X					
0016		X	X														X			X			X																			X		X			X		
0024								X						X	X	X	X		X	X									X		X				X														
0025		X	X					X			X																																						

MOS 35L10 Avionic Communication Repairer Align/Adjust Tasks	Behavioral Element: Set up, connect, and operate: Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/master	Spectrum analyzer	Frequency comparator	Wattmeter	Distortion analyzer	Headset/microphone	Sweep signal generator	Modulation meter	Attenuator	Standing wave ratio ind.	Test facilities/maint. kit	Module test set	Radio test set
Task #113-586-																	
C-6533/ARC	X			X						X					X		
5001	X			X						X					X		
AN/ARC-114	X	X		X	X			X		X		X			X		
5002	X			X	X			X		X		X			X		
5007	X	X		X	X			X		X					X		
AN/ARC-115	X	X		X	X		X	X		X			X		X		
5010	X	X		X	X		X	X		X			X		X		
AN/ARC-116	X	X		X	X		X	X		X			X		X		
5021	X	X		X	X		X	X		X			X		X		
RT-823/ARC/131	X			X	X	X						X			X		X
5051	X			X	X	X						X			X		X
RT-1167/ARC-164	X			X	X			X		X		X	X		X		
5061	X			X	X			X		X		X	X		X		

MOS 35L10 Avionic Communication Repairer Align/Adjust Tasks — Task #113-586- / Behavioral Element	Measure:	Voltage	Frequency	Waveform characteristics	Output	Adjust:	Capacitance - Bend tags w/met.	Capacitance w/frequency meter	Capacitance w/voltmeter	Resistance w/multimeter	Resistance w/oscilloscope	Resistance w/headset	Inductor w/oscolloscope	Inductor w/multimeter	Oscillator tuning slug w/meter	Test set controls w/multimeter	Test set controls w/oscillo.	Attenuation	Mechanical alignment	UUT control/monitor multimeter	Select components/values	Monitor tone on headset	Remove and repiace:	Components	Circuit boards	Modules	Memory drum pins	Fabricate test circuit (diode)	Deseal/seal with RTV component	Calculate (signal+noise)/noise
C-6533/ARC										X						X					X									
5001										X						X					X									
AN/ARC-114		X	X					X	X	X		X				X			X	X		X		X	X	X			X	
5002								X		X		X				X				X		X			X					
5007		X	X					X	X							X			X	X		X		X	X	X			X	
AN/ARC-115				X				X		X	X	X	X			X						X			X					
5010				X				X		X	X	X	X			X						X			X					
AN/ARC-116								X		X		X	X			X	X					X			X					
5021								X		X		X	X			X	X					X			X					
RT-823/ARC-131										X						X														
5051										X						X														
RT-1167/ARC-164										X		X				X						X								
5061										X		X				X						X								

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Behavioral Elements \ Remove and Replace Tasks #113-586-	C-1611D/A1C	4002	AN/ARC-114	4022	4027	AN/ARC-115	4023	4025	AN/ARC-116	4031	4032	RT-348/ARC-54	4038	4039	RT-823/ARC-131	4058	4065	4067	RT-857/ARC-134	4088	RT-1167/ARC-164	4119	5064
Set up, connect & operate:																							
Radio set																							
Oscilloscope																							
Power supply																							
Radio test set																							
TACAN test set																							
Headset																							
Remove & replace: Tube (Electron)																			X	X			
Retaining ring																							
Fasteners																							
Covers, panels	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Circuit cards			X		X	X	X		X		X												
Thumbwheels																							
Connector pins																							
Gaskets																							
Stable element																							
Wiring																							
Clamps																							
Handling fixture																							
Support clamp																							
Safety block																							
Knobs			X	X																			
Cams																							
Ballbearings																							
Gears/gear train																							
Set screws			X	X								X	X										
Panel/mount screws	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
Nuts/bolts															X		X				X	X	
Panel lights																							
Meters																							
Coaxial cables			X		X																		
Dzus fasteners																							
Modules/subassemblies			X		X							X	X	X	X	X	X	X					
Soldered:																							
Leads/harness	X	X	X	X															X	X			
Components																							
Semi-conductors																							
Monitor test set displays																							
Monitor audio signal																							
Verify blower operation																							
Check continuity																							
Apply: Potting compound																							
Sealant			X		X																		
Heat conducting compound																							
Lubricant																							
Mix lubricant																							
Solder/desolder parts			X		X																		
Torque fasteners																							
Clean basket & mate surface																							
Store assembly on foam pad																							
Connect/disconnect:																							
Electrical connectors	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X
Coaxial connectors																							
Stripwire w/thermal stripper												X	X	X	X	X	X	X					
Adjust: Mechanical alignment												X	X		X		X						
Resistor w/headset																							
Resistor w/test set display																							
Interpret mechanical diagrams																							

MOS 35L20 Avionics Communication Repairier Fault Isolation Tasks / Behavioral Elements	Task #113-586- RT-698/ARC-102	0103	0104
Set up, connect and operate:			
Voltmeter/multimeter	x	x	x
Oscilloscope	x	x	x
Frequency counter/meter	x	x	x
Wattmeter			
Signal generator	x	x	x
Spectrum analyzer	x	x	x
Attenuator			
Dummy load			
Power supply	x	x	x
Headset/microphone	x	x	x
Modulation meter			
Frequency comparator			
Decade resistor	x		x
Test facilities/maintenance kit	x	x	x
Radio test set			
Module tester (AN/ARM-87)			
Radio interference meas. set			
Test set (AN/URM-120)			
Test set (TS-1967)			

Figure 2

MOS 35L20 Avionics Communication Repairer Fault Isolation Tasks — Behavioral Elements / Task #113-586-	RT-698/ARC-102	0103	0104
Measure:			
Voltage	x	x	x
Resistance	x	x	
Current			
Power			
Frequency	x	x	x
Continuity	x		x
Waveform characteristics	x	x	x
Distortion			
Frequency deviation			
Mechanical/angular position			
Vacuum tube characteristics			
Identify:			
Symptom	x	x	x
Faulty section	x	x	x
Faulty part	x	x	x
Interpret:			
Fault isolation tables/charts	x	x	x
Schematics/wiring/test point diag.			
Calculate:			
Radio set distortion			
Gain			
S/N, S+N/N ratios			
Difference frequency	x	x	
Percent modulation			
Bandwidth			
Remove/replace:			
Subassembly/module	x	x	x
Circuit board			
Component	x	x	
Cables, wiring	x		x
Monitor:			
Audio signal on headset			
Test set displays/indicators			
UUT displays/indicators			
Adjust:			
Resistor			
Resistor w/oscilloscope			
Inductor w/tuning wand			
Resistor w/voltmeter			
Review symptom list			
Repair wiring			
Assemble/disassemble UUT			
Record test results in digital format			
Perform UUT adjustments	x	x	
Solder/desolder components/wiring			
Perform signal substitution			
Check part value and operation			
Check mechanical operation			

Figure 2 (cont)

MOS 35L20 Avionic Communication Repairer Align/adjust tasks

Set up & connect:

Task #133-586- / Behavioral Element	Voltmeter/multimenter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Spectrum analyzer	Frequency comparator	Wattmeter	Distortion analyzer	Headset/microphone	Sweep signal generator	Modulation meter	Attenuator	Standing wave ratio indicator	Test facilities/maintenance kit	Module test set	Radio test set
AN/ARC-115	X	X		X											X		
5015	X	X		X											X		
5019																	
AN/ARC-116	X	X		X	X		X	X	X	X					X		
5025	X	X		X	X										X		
5026	X	X		X			X	X	X	X					X		
RT-348/ARC-54	X	X		X	X	X									X	X	
8033	X			X	X	X										X	
5038	X	X		X	X										X	X	
RT-742/ARC-51BX	X	X		X				X		X				X	X		
5043	X	X		X				X							X		
5044	X			X				X		X				X	X		
5045	X			X						X					X		
RT-823/ARC-131								X							X		X
5057								X							X		X
RT-857/ARC-134	X	X		X	X			X				X			X		
5058	X	X		X	X			X				X			X		
5060	X	X		X	X			X				X			X		
RT-698/ARC-102	X	X	X	X	X	X		X	X						X		
5069	X	X	X	X	X	X		X	X						X		

MOS 35L20 Avionic Communication Repairer Align/Adjust Tasks — Task #113-586- / Behavioral Element	Measure:	Voltage	Frequency	Waveform characteristics	Output	Adjust:	Capacitance-Bend tabs w/MI	Capacitance w/frequency meter	Capacitance w/voltmeter	Capacitance w/oscilloscope	Resistance w/multimeter	Resistance w/oscilloscope	Resistance w/headset	Inductor w/wand and meter	Inductor w/oscilloscope	Industor w/multimeter	Oscillator tuning slug w/meter	Test set controls w/multimeter	Test set controls w/oscillo.	Attneuation	Mechanical alignment	Select components w/values	Monitor tone on headset	Remove and replace:	Components	Circuit boards	Modules	Memory drum pins	Fabricate test circuit (Diode)	Deseal/seal with rtv component	Calculate (signal+noise)/noise
AN/ARC-115				X					X	X	X																				
5015				X					X	X	X																				
5019																															
AN/ARC-116				X					X	X	X	X							X			X	X		X		X			X	
5025				X					X	X	X								X								X			X	
5026				X							X	X										X	X		X						
RT-348/ARC-54		X	X	X					X		X			X		X		X			X						X				
5033			X						X					X		X					X						X				
5038		X	X	X							X					X		X									X				
RT-742/ARC-51BX		X		X			X		X		X	X	X			X	X	X	X		X						X				
5043		X		X			X		X		X					X	X	X	X		X						X				
5044				X							X	X	X																		
5045											X					X	X	X													
RT-523/ARC-131									X							X															
5057									X							X															
RT-857/ARC-134		X		X	X					X	X	X									X	X			X					X	
5058				X						X	X	X									X	X			X					X	
5060		X		X	X					X	X	X										X			X					X	
RT-698-ARC-102		X	X								X																				
5069		X	X								X																				

MOS 35L20 Avionics Communication Repairer — Behavior Elements / Remove and Replace Tasks #103-586-	RT-857/ARC-134	4076	AN/ARC-114	4020	4100	C-3940/ARC-94	4108	4070	RT-1167/ARC-164	4119	4120	RT-348/ARC-54	4040	4042	4044	4045	RT-742/ARC-51BX	4050	4051	4052	C-6287/ARC-51BX	4047	RT-823/ARC-131	4057
Set up, connect, & operate:																								
Radio set						x		x																
Oscilloscope																								
Power supply																								
Radio test set																								
TACAN test set																								
Headset																								
R & R: Electron tubes												x	x											
Retaining Ring																								
Fasteners																								
Covers, Panels			x	x		x		x	x	x		x	x				x	x	x			x		
Circuit cards																								
Thumbwheels																								
Connector pins						x		x																
Gaskets																								
Stable element																								
Wiring						x		x																
Clamps																								
Handling fixture																								
Support clamp																								
Safety block																								
Knobs	x	x				x		x	x			x	x				x					x		
Cans												x	x											
Ball bearings						x		x	x			x	x											
Gears/gear train												x	x				x					x		
Set screws	x	x				x		x	x			x	x				x					x		
Panel/mount screws	x	x			x	x		x	x	x		x	x				x	x	x			x		
Nuts/bolts	x	x				x		x	x	x		x	x											
Panel lights	x				x	x		x				x	x				x					x		
Meters												x	x											
Coaxial cables						x		x	x	x														
Dzus fasteners						x		x																
Modules/subassemblies			x	x								x	x				x	x	x			x	x	x
Soldered:																								
Leads/harness	x	x										x	x											
Components	x	x										x	x				x					x		
Semi-conductors												x	x											
Monitor test set displays																								
Monitor audio signal																								
Verify blower operation																								
Check continuity																								
Apply: Potting compound																								
Sealant									x	x														
Heat conducting compound																								
Lubricant																								
Mix Lubricant																								
Solder/desolder parts						x		x																
Torque Fasteners																								
Clean gasket & mate surface																								
Store assembly on foam pad																								
Connect/disconnect:																								
Electrical connectors			x	x					x	x		x	x											
Coaxial connectors												x	x											
Stripwire w/thermal stripper																								
Adjust: Mechanical alignment	x	x										x	x				x	x	x			x		
Resistor w/headset																								
Resistor w/test set display																								
Interpret mechanical diagrams																								

MOS 35M10 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks

Behavioral Element: Set up, connect, and operate:

Task #113-585-	Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Watt meter	Spectrum analyzer	Recorder w/preamps	Headset	Output meter	Radio test set	VOR test set	SCAS test set	Pitot-static system tester	Transistor test set	Amplifier test set	Direction finder test set	Test facilities/maintenance kit	Stabilization equipment test set	Rotary actuator test set	Attitude heading reference t.s.	Accelerometer test set	Reference control tester	Gyro-magnetic compass test set	Gyro & compass signal simulator	Gyro instrument/tilt table	Precise angle/angle position ind.	Electron tube test set	Decade resistor	Decade capacitor
R-1391/ARN-83	X	X	X	X											X		X													
0001		X		X													X													
0002	X																X													
0003	X																X													
0004	X														X		X													
0005	X														X		X													
0006	X			X											X		X													
0007	X														X		X													
0008	X														X		X													
0009	X	X		X													X													
0011	X	X		X													X													
0012				X													X													
C-6899/ARN-83																	X													
0016	X																X													
0013	X		X														X													
R-1496/ARN-89	X	X		X														X												
0039				X														X												
0040	X	X		X														X												
0041	X			X														X												
0042	X	X		X														X												
0043	X	X																X												
0044	X	X		X														X												
C-7392/ARN-89																		X												
0045	X	X		X														X												
R-1963/ARN				X		X					X																			
0037				X		X					X																			
0038																														
R-1041,A,B/ARN	X			X		X					X																			

MOS 35M10 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks — Task #113-595-	Behavioral Elements — Measure: Voltage	Resistance	Power	Time	Frequency	Waveform characteristics	Continuity	Angular speed (o/sec.)	Mechanical/angular position	Leakage (rate)	Adjust: Resistance w/oscilloscope	Resistance w/meter	Gyro tilt table	Drift bias	Crystal drums w/meter	Remove and replace: Components	Modules	Gears	Disconnect/connect mechanical linkage	EST transistor w/tester	Test tube w/test set	Verify correct performance param.	Monitor: Tone on headset	Test equipment displays	UUT displays	Calculate: Slaving rate	Static settling points	Settling point difference	RMS scale error	Heading change	Latitude drift rate	Change ( ) heading limits	Attitude change	Pitch/roll excursion	Stage gain	Interpret F.I. charts/tables	Interpret schematic/wiring & test point diagra.	Identify: Symptom	Faulty section	Faulty stage	Faulty component	Select components/values	Perform signal substitutor
R-1391/ARN-83	x	x				x	x														x		x	x	x										x	x				x	x		
0001						x																	x													x				x			
0002	x	x																																							x		
0003	x	x																																							x		
0004	x	x																			x																				x		
0005	x	x																			x																				x		
0006	x	x																			x														x						x		
0007	x	x																			x																				x		
0008	x	x																			x																				x		
0009	x	x				x																																			x		
0011	x	x				x																													x						x		
0012	x	x					x																x																		x		
C-6899/ARN-83																																											
0016		x					x																	x	x																x		
0013		x					x																	x																	x		
R-1496/ARN-89	x	x			x	x	x	x			x						x						x	x	x											x		x	x		x	x	
0039																							x	x														x					
0040	x					x											x						x	x	x														x				
0041	x	x																					x													x					x	x	
0042	x	x				x	x				x														x											x					x	x	
0043	x	x			x																															x					x	x	
0044	x	x				x		x																x	x											x					x	x	
C-7392/ARN-89																																											
0045																							x															x					
R-1963/ARN	x	x	x																					x													x	x			x		
0037																																											
0038																																											
R-1041,A,B/ARN																																											
0094			x																					x														x					
0095	x	x																																			x				x		

MOS 35M10 Avionics Navigation and Flight Control Equipment Repairier Fault Isolation Tasks / Behavioral Element / Task #113-585-	Set up, connect, and operate: Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Wattmeter	Spectrum analyzer	Recorder w/preamps	Headset	Radio test set	VOR test set	SCAS test set	Pitot-static system tester	Transistor test set	Amplifier test set	Direction finder test set	Test facilities/maintenance kit	Stabilization equipment test set	Rotary actuator test set	Module test set	Attitude heading reference t.s.	Accelerometer test set	Reference control tester	Gyro-magnetic compass test set	Gyro & compass signal simulator	Gyro instrument/tilt table	Precise angle/angle position ind.	Electron tube test set	Decade resistor	Decade capacitor
CN-798/ASN-43	X																									X	X			
0048																										X	X			
0055	X																									X	X			
0056																										X	X			
AH-1 SCAS	X	X	X									X																		
0062												X																		
0063	X	X	X									X																		
0065	X	X	X									X																		
0066	X	X	X									X																		
CH-47 SAS	X																	X												
0074																		X												
0077	X																	X												
0078	X																	X												
0079	X																	X												
0080	X																	X												
0081	X																	X												
0082	X																													
CH-47 Speed Trim Amp													X	X																
0084													X	X																
0085													X	X																
0086														X																
0087														X																
0088														X																
0089														X																

MOS 35M10 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks / Task #113-585- / Behavioral Element	CN-996/ASN-43	0048	0055	0056	AH-1 SCAS	0062	0063	0065	0066	CH-47 SAS	0074	0077	0078	0079	0080	0081	0082	CH-47 Speed Trim Amp	0084	0085	0086	0087	0088	0089
Measure:																								
Stage gain																								
Voltage	x		x		x		x	x	x									x		x	x	x	x	x
Resistance	x		x		x			x		x		x	x	x	x	x	x	x		x	x	x	x	x
Output																								
Time	x	x		x																				
Frequency																								
Waveform characteristics					x		x	x	x															
Continuity										x		x												
Angular speed (o/sec.)																								
Mechanical/angular position	x	x		x																				
Leakage (rate)																								
Adjust:																								
Resistance w/oscilloscope										x			x											
Resistance w/meter																								
Gyro tilt table	x	x		x																				
Drift bias	x	x		x																				
Crystal drums w/meter																								
Remove and replace:																								
Components																								
Modules					x		x	x		x		x												
Gears																								
Disconnect/connect mechanical linkage																								
Test transistor w/tester																								
Test tube w/test set																								
Verify correct performance param.																								
Monitor:																								
Tone on headset																								
Test equipment displays					x	x	x	x		x	x	x	x	x				x	x		x	x	x	x
UUT displays	x	x		x	x	x				x	x							x	x					
Calculate:																								
Slaving rate	x	x		x																				
Static settling points	x	x		x																				
Settling point difference	x	x		x																				
RMS scale error	x	x		x																				
Heading change	x	x		x																				
Latitude drift rate	x	x		x																				
Change ( ) heading limits	x	x																						
Attitude change																								
Pitch/roll excursion																								
Interpret F.I. charts/tables	x				x	x	x	x	x	x		x						x	x					
Interpret schematic/wiring & test point diagrams	x									x			x	x	x	x	x	x	x	x		x	x	x
Identify:																								
Symptom	x	x			x	x	x	x	x	x	x							x	x					
Faulty section										x		x						x		x				
Faulty stage																								
Faulty component	x			x	x	x	x	x	x	x			x	x	x	x	x	x	x		x	x	x	x
Select components/values	x			x	x		x	x	x	x		x						x	x		x			
Perform signal substitution																								

MOS 35M10 Avionics Navigation and Flight Control Equipment Repairer Align/Adjust Tasks Task #113-585-	Behavioral Elements Set up, connect, and operate: Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Wattmeter	Modulator	Spectrum analyzer	Headset	Directin finder test set	Stabilization equipment test set	Radio test set	Pitot-static system test set	Amplifier test set	Aircraft displacement simulator	Test facilities/maintenance kit	Resistance bridge	Decade resistor	Rotary actuator test set	Gyro test set	Gyro tilt table	Electron tube test set	Attenuator	Maintenance kit
R-1391/ARN-83	X		X	X		X			X	X														
5001			X							X														
5002			X							X														
5003	X		X	X						X														
5004			X	X		X			X	X														
5005			X	X		X			X	X														
5006			X	X		X				X														
5007			X	X		X			X	X														
5008			X	X		X				X														
5009			X	X		X			X	X														
5010			X							X														
5011			X	X					X	X														
C-6899/ARN-83																								
5013			X							X														
R-1388/ARN-82	X	X	X	X	X		X					X												
5014	X	X	X	X	X		X					X												
5015	X	X	X	X	X		X					X												
5021	X		X	X			X					X												
5022	X		X	X			X					X												
5023	X		X	X			X					X												
5024	X	X	X	X			X					X												
5025			X	X			X					X												

MOS 35M10 Avionics Navigation and Flight Control Equipment Repairer Align/Adjust Tasks — Behavioral Elements / Task #113-585-	Measure:	Angular speed (o/sec.)	Time	Angular/mechanical position	Leakage (rate)	Continuity	Adjust:	Capacitance w/frequency meter	Capacitance w/meter	Capacitance w/headset	Resistance w/gear train	Resistance w/angular speed	Resistance w/meter	Inductor w/frequency meter	Inductor w/headset	Inductor w/wand and meter	Transformer w/meter	Test set controls w/meter	Test set controls w/headset	Resolver	Pressure w/gauge	Mechanical alignment	Cams/slipclutch	Thermal delay relay	Remove and replace:	Components	Soldered covers	Connect/disconnect pressure line	Drill hole in cam & shift	Fabricate and install shims	Safety wire components	Select components/values	Monitor tone on headset
R-1391/ARN-83									X	X	X	X	X		X		X	X	X			X					X						X
5001											X																						
5002																						X											
5003																		X				X											
5004										X					X				X								X						X
5005									X								X		X								X						X
5006													X					X															
5007									X								X	X	X								X						X
5008																		X															
5009																			X			X											X
5010												X	X																				
5011													X					X	X														
C-6899/ARN-83																																	
5013																		X				X											
R-1388/ARN-82			X						X				X	X			X	X		X		X				X						X	X
5014									X				X	X			X									X						X	
5015									X				X	X			X									X						X	
5021													X																				
5022													X					X				X											
5023			X										X					X		X		X				X							X
5024			X																	X													
5025													X									X											

MOS 35M10 Avionics Navigation and Flight Control Equipment Repairer Align/Adjust Tasks / Behavioral Elements — Task #113-585-	Set up, connect, and operate: Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Wattmeter	Modulator	Spectrum anlayzer	Headset	Stopwatch	Direction finder test set	Stabilization equipment test set	Radio test set	Pitot-static system test set	Amplifier test set	Aircraft displacement simulator	Test facilities/maintenance kit	Resistance bridge	Decade resistor	Rotary actuator test set	Gyro test set	Gyro tilt table	Electron tube test set	Attitude reference control test set
CH-47 SAS	X											X		X	X	X		X	X					
5031	X											X				X								
5032	X											X				X								
5033	X											X				X								
5034	X											X				X								
5035	X											X				X								
5036	X											X							X					
5037	X													X	X			X						
5038	X													X	X			X						
5039	X													X	X			X						
5072	X													X	X			X						
5073	X													X	X			X						
5074	X											X		X				X						
5075	X											X		X				X						
R-1496/ARN-89			X										X											
5027			X										X											
CN-998/ASN-43	X																	X						
5028	X																	X						
5029	X																	X						
R-1041B/ARN			X	X	X	X							X											
5040			X	X	X	X							X											
C-3108/ASW-12(V)	X									X									X					X
5069	X									X									X					X
5070	X									X									X					X

MOS 35M10 Avionics Navigation and Flight Control Equipment Align/Adjust Tasks / Behavioral Element	Measure:						Adjust:																	Remove and replace:												
Task #113-585-	Angular speed (o/sec.)	Time	Angular/mechanical position	Leakage (rate)	Continuity	Voltage	Capacitance w/frequency meter	Capacitance w/meter	Capacitance w/headset	Resistance w/gear train	Resistance w/angular speed	Resistance w/meter	Inductor w/frequency meter	Inductor w/headset	Inductor w/wand and meter	Transformer w/meter	Test set controls w/meter	Test set controls w/headset	Resolver	Pressure w/gauge	Mechanical alignment	Cams/slipclutch	Thermal delay relay	Components	Soldered covers	Connect/disconnect pressure line	Drill hole in cam & shift	Fabricate and install shims	Safety wire components	Select components/values	Determine geoniometer compensation	Monitor tone on headset	Identify resistance by color code	Solder/desolder component	Connect/disconnect electric comp.	Assemble/disassemble unit
CH-47 SAS		X		X		X						X				X	X			X				X		X				X						
5031		X				X											X																			
5032		X				X											X																			
5033		X				X											X																			
5034																	X			X																
5035																	X			X																
5036												X				X				X				X		X				X						
5037				X		X						X				X				X				X		X										
5038												X								X				X		X										
5039												X					X			X						X										
5072												X								X						X										
5073												X								X						X										
5074												X					X			X						X										
5075				X												X	X			X						X										
R-1496/ARN-89																	X													X						
5027																	X													X						
CN-998/ASN-43								X				X												X												
5028								X				X												X												
5029												X																								
R-1041B/ARN												X				X	X							X						X						
5040												X				X	X							X						X						
C-3108/ASW-12(V)		X				X																											X	X	X	X
5069		X				X																											X	X	X	X
5070		X				X																											X	X	X	X

OS 35M10 vionics avigation and Flight Control Equipment Repairer Remove and Replace Tasks

Behavioral Elements / Task #113-585-	C-6899/ARN-83	4001	4002	R-1391/ARN-83	4003	4004	R-1388/ARN-82	4008	4009	R-1496/ARN-89	4015	CH-47 SAS	4027
Set up, connect, and operate:													
Oscilloscope													
Power supply													
Radio test set													
TACAN test set													
Headset													
Remove and replace:													
Retaining ring	x	x	x										
Fasteners													
Covers, panels	x	x	x		x	x	x	x	x				
Circuit cards												x	x
Thumbwheels													
Connector pins													
Gaskets												x	x
Stable element													
Wiring													
Clamps													
Handling fixture													
Support clamp													
Safety block													
Knobs	x	x	x										
Resis-er												x	x
Cams													
Ballbearings	x				x	x	x	x	x				
Gears/gear train	x	x	x		x	x	x	x	x				
Set screws	x	x	x		x	x	x	x	x				
Panel/mount screws	x	x	x		x	x	x	x	x			x	x
Nuts/bolts										x	x	x	x
Panel lights													
Meters	x	x	x										
Coaxial cables													
Dzus fasteners	x	x	x										
Modules/subassemblies	x				x	x	x	x	x	x	x	x	x
Soldered:													
Leads/harness	x	x	x							x	x		
Components													
Semi-conductors													
Monitor test set displays													
Monitor audio signal													
Verify blower operation													
Check continuity													
Apply: Potting compound													
Sealant													
Heat conducting compound													
Lubricant	x		x			x	x		x			x	x
Mix lubricant	x					x							
Solder/desolder parts												x	x
Torque fasteners													
Clean gasket & mate surface													
Store assembly on foam pad													
Connect/disconnect:													
Electrical connectors												x	x
Coaxial connectors													
Stripwire w/thermal stripper													
Adjust: Mechanical alignment	x		x			x	x		x				
Resistor w/headset													
Resistor w/test set display													
Interpret mechanical diagrams													
Assemble/disassemble UUT										x	x	x	x

MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks / Behavioral Element — Task #113-585-	Set up, connect, and operate: Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Watt meter	Spectrum analyzer	Recorder w/preamps	Headset	Modulator	Frequency converter	Radio test set	VOR test set	SCAS test set	Pitot-static system tester	Transistor test set	Amplifier test set	Direction finder test set	Test facilities/maintenance kit	Stabilization equipment test set	Rotary actuator test set	Module test set	Attitude heading reference t.s.	Accelerometer test set	Reference control tester	Gyro-magnetic compass test set	Gyro & compass signal simulator	Gyro instrument/tilt table	Precise angle/angle position ind	Electron tube test set	Decade resistor	Decade capacitor
R-1382/ARN-82	X	X		X	X								X																			
0018																																
0019	X			X									X																			
0020	X			X									X																			
0021	X			X									X																			
0022	X			X									X																			
0023	X			X									X																			
0024	X			X									X																			
0025	X			X									X																			
0026	X			X	X								X																			
0027	X			X	X								X																			
0028	X			X									X																			
0029	X			X									X																			
0030	X	X		X									X																			
0032	X	X		X									X																			
0033	X	X		X									X																			
0034	X	X		X									X																			
0035	X	X		X									X																			
R-2023/ARN-123	X		X	X		X				X	X	X																				
0090	X		X	X						X		X																				
0091	X		X	X																												
0092				X		X						X																				
0096				X							X	X																				
C-10048/ARN-123 or C-10049/ARN-123																																
0093	X		X																													

Figure 2 (cont)

MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks / Behavioral Elements / ask #113-585-	Measure:	Stage gain	Voltage	Resistance	Output	Time	Frequency	Waveform characteristics	Continuity	Angular speed (o/sec.)	Mechanical/angular position	Leakage (rate)	Adjust:	Resistance w/oscilloscope	Resistance w/meter	Gyro tilt table	Drift bias	Crystal drums w/meter
R-138 /ARN-82			X	X			X	X										
0018																		
0019			X															
0020			X	X														
0021			X															
0022			X															
0023			X	X														
0024			X	X														
0025			X	X														
0026			X	X			X											
0027			X	X			X											
0028			X	X														
0029			X	X														
0030			X	X				X										
0032			X	X				X										
0033			X	X				X										
0034			X	X				X										
0035			X	X				X										
R-2023/ARN-123				X					X									
0090																		
0091																		
0092																		
0096																		
C-10048/ARN-123 or C-10049/ARN-123																		
0093				X					X									

Task	Remove and replace:	Components	Modules	Gears	Disconnect/connect mechanical linkage	Test transistor w/tester	Test tube w/test set	Verify correct performance param.	Monitor:	Tone on headset	Test set displays	UUT displays	Connect/disconnect cables	Calculate:	Slaving rate	Static settling points	Setting point difference
R-138 /ARN-82																	
0018																	
0019																	
0020																	
0021																	
0022																	
0023																	
0024																	
0025																	
0026																	
0027																	
0028																	
0029																	
0030																	
0032																	
0033																	
0034																	
0035																	
R-2023/ARN-123											X			X			
0090											X						
0091											X						
0092											X						
0096											X			X			
C-10048/ARN-123 or C-10049/ARN-123																	
0093																	

Task	RMS scale error	Heading change	Latitude drift rate	Change ( ) heading limits	Attitude change	Pitch/roll excursion	Stage gain	Interpret F.I. charts/tables	Interpret schematic/wiring & test point diagrams	Identify:	Symptom	Faulty section	Faulty stage	Faulty component	Select components/values	Perform signal substitution
R-138 /ARN-82							X	X				X	X	X		
0018								X				X				
0019							X						X			
0020							X							X		
0021							X						X			
0022							X						X			
0023														X		
0024														X		
0025														X		
0026														X		
0027														X		
0028														X		
0029														X		
0030														X		
0032														X		
0033														X		
0034														X		
0035														X		
R-2023/ARN-123																
0090																
0091																
0092																
0096																
C-10048/ARN-123 or C-10049/ARN-123																
0093																

Figure 2 (cont)

Set up, correct, and operate:

MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks / Task #113-585- / Behavioral Element	Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Wattmeter	Spectrum analyzer	Recorder w/preamps	Headset	Demodulator	Stopwatch	Bench test set	Radio test set	VOR test set	SCAS test set	Pitot-static system tester	Transistor test set	Amplifier test set	Direction finder test set	Test facilities/ maintenance kit	Stabilization equipment t.s	Rotary actuator test set	Module test set	Attitude heading reference test set	Accelerometer test set	Reference control tester	Gyro-magnetic compass t.s.	Gyro & compass signal simulator	Gyro instrument/tile table	Precise angle/angle position ind.	Electron tube test set	Decade resistor	Decade capacitor	Navigational coupler subassembly test set
CV-265A/ARN-30	X		X	X	X				X																						X			
0221	X		X	X	X				X																						X			
R-1031/ARN-30																																		
0220	X		X	X	X				X																						X			
CN-601/ASN-12	X		X					X		X	X	X				X						X			X		X		X					X
0202	X		X																								X		X					
0203	X																										X		X					
CV-792/ASW-12																																		
0205	X							X		X	X	X																						
0206	X							X		X	X	X																						
0207	X																																	X
0208	X																																	X
0209	X																																	
C-3106/ASW-12																																		
0217	X															X																		
MX-2917,8,9/ASW-12																																		
0193	X		X																															
0196	X																																	
0199	X																								X				X					
C-3107/ASW-12																																		
0201	X		X																															
TG-78,79,80,81/ ASW-12																																		
0186	X																					X												
0192	X																																	
C-3106/ASW-12(V)																																		
8036	X											X				X																		
8037	X																																	
8038	X																																	
8039	X																																	
8040	X																																	

Figure 2 (cont)

MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks

Task #113-585- / Behavioral Element	Measure:	Stage gain	Voltage	Resistance	Output	Time	Frequency	Waveform characteristics	Continuity	Angular speed (o/sec.)	Mechanical/angular position	Leakage (rate	Capacitance	Adjust:	Resistance w/oscilloscope	Resistance w/meter	Gyro tilt table	Drift bias	Crystal drums w/meter	Remove and replace:	Components	Modules	Gears	Disconnect/connect mechanical linkage	Test transistor w/tester	Test tube w/test set	Verify correct performance param.	Monitor:	Tone on headset	Test equipment displays	UUT displays	Check diodes	Calculate:	Slaving rate	Static settling points	Settling point difference	RMS scale error	Heading change	Latitude drift rate	Change ( ) heading limits	Attitude change	Pitch/roll excursion	Stage gain	Interpret F.I. charts/tables	Interpret schematic/wiring & test point diagrams	Identify:	Symptom	Faulty section	Faulty stage	Faulty component	Solder/desolder	Select components/values	Perform signal substitution
CV-265A/ARN-30			X	X					X							X			X			X				X																	X	X	X		X	X	X	X			X
0221			X	X					X													X				X																		X	X		X	X	X	X			X
R-1031/ARN-30																																																					
0220			X	X					X							X			X			X				X																	X	X	X		X	X	X				X
CN-601/ASW-12			X	X	X	X			X			X	X			X	X				X	X	X							X	X	X												X	X		X	X	X	X	X		
0202			X	X		X			X								X																											X			X	X	X	X			
0203				X													X																											X	X		X	X	X				
CU-792/ASW-12																																																					
0205						X																								X	X																			X			
0206			X	X	X				X												X	X								X																				X			
0207																														X																	X						
0208				X					X				X			X						X									X																						
0209			X																											X																	X						
C-3106/ASW-12																																																					
0217			X	X					X			X									X																																
MX-2917,8,9/ASW-12																																																					
0193				X																	X	X																									X						
0196				X																	X																													X			
0199																																															X						
C-3107/ASW-12																																															X						
0201			X																																																		
TG-78,79,80,81/ ASW-12																																																					
0186																																																					
0192			X	X																	X	X	X																						X		X			X			
C-3106/ASW-12(V)																																																					
8036																															X																						
ME-26																																																					
8037						X			X																																												
8038						X																									X																						
8039									X																						X																						
8040			X																																																		X

Figure 2 (cont)

MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks

Behavioral Element: Set up, connect, and operate:

Task #113-585-	Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Wattmeter	Spectrum analyzer	Recorder w/preamps	Headset	Bench test set	Radio test set	VOR test set	SCAS test set	Pitot-static system tester	Transistor test set	Amplifier test set	Direction finder test set	Test facilities/ maintenance kit	Stabilization equipment test set	Rotary actuator test set	Module test set	Attitude heading reference test set	Accelerometer test set	Attitude reference control tester	Gyro-magnetic compass t.s.	Gyro & compass signal simulator	Gryo instrument/tilt table	Precise angle/angle position ind.	Electron tube test set	Decade resistor	Decade capacitor	Auto pilot altitude control bench test analyzer	Test set sub ssembly	Attenuator	Navigation set mount
CV-1275/ARN	X		X	X							X				X																		X	X	X
0222	X		X	X							X																						X	X	X
R-8320/ARN-59	X	X		X	X	X	X		X		X				X														X						
0219	X	X		X	X	X	X		X		X				X														X						
C-3108/ASW-12	X		X											X										X											
0213	X																																		
0214	X																																		
0215	X																																		
0218	X		X																					X											
8034	X													X										X											
A2/J2 Compass	X	X		X	X																				X				X		X				
0216	X	X		X	X																				X				X		X				
AM-4682/ASN-76	X																				X	X				X	X	X		X					
0181	X																									X		X							
0182	X																				X					X		X							
0183																																			
C-8099/ASN-76																																			
0184	X																					X								X					
0185																																			
C-1151/ASN-76																																			
0179																						X					X	X							
0180																					X														
C-6873/ARN-82	X											X		X																					
0017	X											X		X																					
C-3106/ASW-12	X		X							X				X									X												
8035	X									X				X																					
8029	X																						X												
8030	X																						X												
8031	X		X																				X												
8032	X		X																				X												
8033	X		X																				X												

Figure 2 (cont)

MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks

Behavioral Element / Task #113-585-	Measure:	Stage gain	Voltage	Resistance	Output	Time	Frequency	Waveform characteristics	Continuity	Angular speed (o/sec.)	Mechanical/angular position	Leakage (rate)	Capacitance	Adjust:	Resistance w/oscilloscope	Resistance w/meter	Gyro tilt table	Drift bias	Crystal drums w/meter	Remove and replace:	Components	Modules	Gears	Disconnect/connect mechanical linkage	Test transistor w/tester	Test tube w/test set	Verify correct performance param.	Monitor:	Tone on headset	Test equipment displays	UUT displays	Calculate:	Slaving rate	Static setting points	Settling point difference	RMS scale error	Heading change	Latitude drift rate	Change ( ) heading limits	Attitude change	Pitch/roll excursion	Interpret F.I. charts/tables	Interpret schematic/wiring & test point diagrams	Identify:	Symptom	Faulty section	Faulty stage	Faulty component	Visual inspection	Select components/values	Perform signal substitution
CV-1275/ARN				X					X																					X	X															X	X	X	X		
0222				X					X																					X	X															X	X	X	X		
R-836/ARN-59				X					X													X		X		X			X													X			X	X	X	X			X
6219				X					X													X		X		X			X													X			X	X	X	X			X
C-3108/ASW-12			X	X		X			X							X					X	X																				X	X		X	X	X				
0213			X	X																																						X				X					
0214				X																																									X		X				
0215				X																																						X			X						
0218			X	X		X			X							X																										X	X		X						
8034			X						X							X					X	X																													
A2/J2 Compass			X	X					X																	X																			X	X					
0216			X	X					X																	X																			X	X					
AM-4682/ASN-76			X	X		X					X					X	X				X			X							X						X			X	X	X			X			X			
0181			X	X							X										X										X											X			X						
0182			X	X							X					X																										X			X						
0183																					X																					X			X			X			
C-8099/ASN-76																																																			
0184			X	X																																						X			X						
0185																					X	X																				X						X			
C-1151/ASN-76																																																			
0179			X			X											X												X								X			X	X				X						
0180			X	X		X			X																																				X						
C-6873/ARN-82				X					X																																										
0017				X					X																																										
C-3106/ASW-12																															X																	X			
8035																															X																	X			
8029																															X																				
8030																															X																				
8031																															X																				
8032																															X																				
8033																															X																				

Figure 2 (cont)

MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Align/Adjust Tasks Behavioral Elements Set up, connect, and operate: Task #113-585-	Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Wattmeter	Modulator	Spectrum analyzer	Headset	Direction finder test set	Stabilization equipment test set	Radio test set	Pitot-static system test set	Amplifier test set	Aircraft displacement simulator	Test facilities/maintenance kit	Resistance bridge	Decade resistor	Rotary actuator test set	Gyro test set	Gyro tilt table	Electron tube test set	Attenuator
R-836/ARN-59	X			X	X	X		X	X			X											
5052	X			X	X	X		X	X			X											
ACW-12	X	X																X	X	X	X		
5053	X																	X	X				
5054																							
5055	X																						
5056	X																						
5057																							
5058	X																						
5060																							
5061																							
5062	X																						
5064	X																						
5065	X																						
5066																							
5067	X	X																		X	X		
5068	X																						
J2 Compass	X																						
5071	X																						
CV-265/ARN-30	X		X	X	X				X													X	
5076	X		X	X	X				X													X	
C-1021/ARN-30																							
5077	X		X	X	X				X													X	
CV-1275/ARN	X		X	X								X				X							X
5078	X		X	X								X				X							X

MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Align/ Adjust Tasks / Behavioral Element — Task #113-585-	Measure:	Angular speed (o/sec.)	Time	Angular/mechanical position	Leackage (rate)	Continuity	Adjust:	Capacitance w/frequency meter	Capacitance w/meter	Capacitance w/headset	Resistance w/gear train	Resistance w/angular speed	Resistance w/meter	Inductor w/frequency meter	Inductor w/headset	Industor w/wand and meter	Transformer w/meter	Test set controls w/meter	Test set controls w/headset	Resolver	Pressure w/gauce	Mechanical alignment	Cams/slipclutch	Thermal delay relay	Gear w/meter	Remove and replace:	Components	Soldered covers	Connect/disconnect pressure line	Drill hole in cam and shaft	Fabricate and install shims	Safety wire components	Select components/values	Monitor tone on headset
R-836-ARN-59		X									X																							
5052		X									X																							
ASW-12		X	X			X						X										X	X	X			X			X	X	X	X	
5053													X														X						X	
5054																							X											
5055						X																X												
5056		X				X																X												
5057																											X					X		
5058																						X	X											
5059																															X			
5060						X																									X			
5061																						X												
5062						X																X												
5064																							X											
5065		X											X									X					X			X				
5066																						X												
5067			X																													X		
5068		X	X																					X			X							
J2 Compass																																		
5071																																		
CY-265/ARN-30									X				X			X						X					X							
5076													X																					
R-1021/ARN-30																																		
5077									X				X			X						X					X							
CV-1275-ARN													X							X					X		X							
5078													X							X					X		X							

MOS 35R10 Avionics Special Equipment Repairer Fault Isolation Tasks / Task #113-610- — Behavioral Element: Set up, connect, and operate:	Voltmeter/multimeter	Oscilloscope	Signal generator	Wattmeter	Frequency counter	Power supply	Pulse generator	Frequency comparator	Time mark generator	Standing wave indicator	Transfer oscillator	Square law detector	Echo box	Variable attenuator	Variable transformer	Recorder w/preamps	Tape reader	Decade synchro bridge	UUT	Radar altimeter test set	Module test set	TACAN test set
RT-711/APN-158	X	X	X	X	X		X			X				X					X			
0026	X	X	X	X	X									X								
SN-358/APN-158																						
0027		X	X				X															
P-72A/APN-158																						
0028	X	X					X															
AS-1500/APN-158 (or -1642)																						
0029	X		X		X					X												
C-4881/APN-158																						
0030	X																		X			
RT-859A/APX-72		X			X	X													X			
0043						X													X			
0044		X			X																	
RT-804/APN-171	X	X	X	X																X	X	
0033	X	X	X	X																X	X	
0038	X	X																		X		
D-1345/APN-171																						
0032	X																			X		
RT-1057/ARN-103	X																					X
0045	X																					X
C-8968/ARN-103																						
0046																						X

MOS 35R10 Avionics Special Equipment Repairer Fault Isolation Tasks / Task #113-610- — Behavioral Element: Set up, connect, and operate:	Radio test set	Radar test set	Transponder test set	Simulator test set	Pulse power test set	RF power test set	Inertial navigation test set	Gyro stabilized platform t.s.	Test facilities kit	Gyro stabilized platform test stand	Computer mount	Purge and fill unit	Stopwatch	Test tapes	Thermistor mount	Antenna Mounting fixture	Carriage	Slotted section	Headset	Probe	Battery	Pressurize unit
RT-711/APN-158		X							X						X		X	X	X	X		
0026		X							X						X							
SN-358/APN-158																						
0027		X							X													
P-72A/APN-158																						
0028		X							X													
AS-1500/APN-158 (or -1642)																						
0029		X															X	X	X	X		
C-4881/APN-158																						
0030		X																				
RT-859A/APX-72		X	X	X																		X
0043			X																			X
0044		X	X	X																		
RT-804/APN-171													X									
0033																						
0038																						
D-1345/APN-171																						
0032													X									
RT-1057/ARN-103	X																		X			
0045	X																		X			
C-8968/ARN-103																						
0046																			X			

MOS 35R10 Avionics Special Equipment Repairer Fault Isolation Tasks / Task #113-610- — Behavioral Elements	AN/APM-305A	8012	0082	0083	0084
Set up, connect, and operate:					
Voltmeter/multimeter	X			X	X
Oscilloscope	X	X	X	X	X
Signal generator	X			X	X
Wattmeter	X				X
Frequency counter	X			X	X
Power supply	X				X
Pulse generator	X			X	X
Frequency comparator	X			X	X
Time mark generator	X				X
Standing wave indicator					
Transfer oscillator	X			X	
Square law detector	X			X	X
Echo box					
Variable attenuator					
Variable transformer	X			X	X
Recorder w/preamps					
Tape reader					
Decade synchro bridge					
UUT	X	X	X	X	X
Radar altimeter test set					
Module test set					
TACAN test set					
Radio test set					
Radar test set					
Transponder test set	X	X		X	X
Simulator test set					
Pulse power/t.s./calibrator meter	X			X	X
RF power t.s./RF power meter	X			X	X
Inertial navigation test set					
Gyro stablized platform t.s.					
Differential voltmeter	X			X	
Test facilities kit					
Gyro stablisized platform test stand					
Computer mount					
Purge and fill unit					
Stopwatch					
Test tapes					
Thermistor mount					
Antenna mounting fixture					
10K ohm resistor	X			X	
Carriage					
Slotted section					
Headset					
Probe					
Battery	X				X
Disconnect/connect cable/connector	X	X	X	X	X
Check: Sweep sync	X			X	
rf source marker	X			X	
if input	X			X	
R/R screws, nuts, lockwashers	X			X	
Tag wires	X			X	
R/R pad, filter	X			X	
Load	X			X	

MOS 35R10 Avionics Special Equipment Repairer Fault Isolation Tasks / Behavioral Element / Task #113-610-	Measure:	Voltage	Resistance	Power	Time	Frequency	Waveform characteristics	Suppression count	Degrees w/syncro bridge	Check continuity	Calculate:	Total loop attenuation	Cable length	Stage gain	Bandwidth	Average power out	Difference voltage	Peak power	Receiver sensitivity	Sideband w/cal. curves	Center frequencies	Power w/cal. curves	Signal/noise ratio	Drift rate	Monitors test set displays	UUT displays	Audio on headset	Signal generator	Standing wave indicator	Recorder waveform	Identify symptom	Identify faulty component	Interpret charts/tables	Interpret schematics/wiring/test point diagrams	Verify correct performance param.	Adjust: Resistor w/meter	Resistor w/oscilloscope	Resistor w/test set display	Connector body w/meter	Transformer w/wand & scope	Capacitor	Resistor w/UUT display	Antenna position	Resolver	UUT controls	Load and run tapes	Remove and replace: Covers	Components	Modules	Lamps	Cables	Circuit card.	Fabricated cable	Align Synchro	Perform leak test	Check blower operation
RT-7 1/APN-158		X		X	X	X	X			X		X		X	X	X	X	X					X		X	X		X	X		X	X	X			X	X	X		X		X	X	X			X	X						X		X
0026		X		X	X	X	X					X				X	X	X							X	X					X		X			X	X										X	X								
SN-358/APN-158																																																								
0027							X			X				X	X								X		X			X			X		X				X	X		X							X	X								
P/724/APN-158																																																								
0028		X					X																		X	X					X		X			X						X	X				X									
AS-1500/APN-158																																																								
or -1642) 0029		X					X																		X	X			X		X		X			X		X				X	X	X										X		
C-4881/APN-158																																																								
0030		X																														X																								
RT-859A/APX-72					X		X					X		X					X	X	X									X																										
0043																																																								
0044					X		X					X		X					X	X	X									X																										
RT-804/APN-171		X	X	X			X			X		X	X	X											X	X		X			X		X	X	X	X		X	X								X	X	X	X			X			X
0033		X	X	X			X			X		X		X											X			X			X		X	X	X	X			X									X								
0038		X					X			X															X						X		X	X	X	X		X									X		X				X			X
D-1345/APN-171																																																		X						
0032		X			X							X	X												X	X					X		X		X																					
RT-1057/ARN-103										X		X													X		X				X		X		X														X		X					X
0045										X		X													X		X				X		X		X														X		X					X
C-8968/ARN-103																																																								
0046																									X		X				X				X																					
AN/APM-305A		X	X				X			X																X					X	X	X	X	X										X		X	X	X	X	X	X				
8012							X																			X					X	X			X										X											
0082							X																			X					X														X											
0083		X	X				X			X																X					X	X	X	X											X		X	X	X	X	X	X				
0084							X																			X					X		X												X											

MOS 35R10 Avionics Special Equipment Repairer Align/Adjust Tasks / Behavioral Elements — Task #113-610-	Set up, connect, and operate: Voltmeter/multimeter	Oscilloscope	Signal Generator	Wattmeter	Pulse generator	Sweep frequency generator	Headset	Recorder w/preamps	Frequency counter/meter	Horizontal situation indicator (HSI	Variable transformer	TACAN test set	Radio test set	Radar altimeter test set	Module test set	Transponder test set	Radar test set	Test facilities/maintenance kit	Dummy load tester	Simulator test set	Gyro stabilized platform test set and stand	Differential voltmeter	Square detector	Pulse power calibrator set	RF power test set	10 K ohm resister	Digital voltmeter	Transfer oscillator	Comparator frequency
RT-804/APN-171	X	X	X	X										X	X														
5008	X	X												X															
5009		X	X	X										X	X														
RT-1057/ARN-103		X					X			X		X	X																
5017		X					X			X		X	X																
SN-358/APN-158A		X	X		X												X	X											
5013		X	X		X												X	X											
IP-724/APN-158A																													
5014																	X												
RT-859A/ A-72	X	X	X	X		X			X							X	X		X	X									
5015	X	X	X	X		X			X							X	X		X	X									
AN/APM-305A	X	X	X		X				X		X					X						X	X	X	X	X	X	X	X
5019	X	X	X		X				X		X					X						X	X	X	X	X	X	X	X

MOS 35R10 Avionics Special Equipment Repairer Align/Adjust Tasks / Task #113-610- \ Behavioral Elements	Measure: Waveform characteristics	Voltage	Suppression count	Power	Adjust: Resistor w/UUT display	Resistor w/meter	Resistor w/oscilloscope	Resistor w/test set display	Transformer w/oscilloscope	Tuning screw w/oscilloscope	Capacitor w/oscilloscope	Capacitor w/test set display	Test set control w/oscilloscope	Test set control w/UUT display	Test set control w/meter	UUT	Remove & replace covers	Monitor recorder waveforms	Assemble/disassemble UUT	Remove and replace module	Calculate: Total loop attenuation	Bandwidth	Center frequency	Power w/calibration curves	Drift direction	Drift in arc minutes	Drift rate (o/Hr)	Required adjustment	Loosen/tighten: Screws/nuts	Monitor test set displays	Connect/disconnect cable	Scrape RTV/coat w/RTV
RT-804/APN-171	X					X	X	X		X			X	X	X		X		X		X											
5008	X					X	X	X		X				X	X		X				X											
5009										X			X						X													
RT-1057/ARN-103					X											X	X			X									X	X	X	X
5017					X											X	X			X									X	X	X	X
SN-358/APN-158A	X				X	X	X	X					X																			
5013	X					X	X	X																								
IP-724/APN-158A																																
5014					X									X																		
RT-859A/APX-72	X	X	X	X		X	X				X	X			X				X			X	X	X								
5015	X	X	X	X		X	X				X	X			X				X			X	X	X								
AN/APM-305A	X															X													X		X	
5019	X															X													X		X	

MOS 35R10 Avionics Special Equipment Repairer Remove and Replace Tasks

Task 4113-610- / Behavioral Elements	Set up, connect, and operate:	Oscilloscope	Power supply	Radio test set	TACAN test set	Headset	Remove and replace:	Retaining ring	Fasteners	Covers, panels	Circuit cards	Thumbwheels	Connector pins	Gaskets	Stable element	Wiring	Clamps	Handling fixture	Support clamp	Safety block	Knobs	Cans	Ballbearings	Gears/gear train	Set screws	Panel/mount screws	Nuts/bolts	Panel lights	Meters	Coaxial cables	Dzus fasteners	Modules/subassemblies	Soldered:	Leads/harness	Components	Semi-conductors	Monitor test set displays	Monitor audio signal	Verify blower operation	Check continuity	Apply: Potting compound	Sealant	Heat conducting compound	Lubricant	Mix Lubricant	Solder/desolder parts	Torque fasteners	Clean gasket & mate surface	Store assembly on foam pad	Connect/disconnect:	Electrical connectors	Coaxial connectors	Stripwire w/thermal stripper	Adjust: Mechanical alignment	Resistor w/headset	Resistor w/test set display	Interpret mechanical diagrams
RT-711/APN-158A									X	X																									X																X						X
4014									X	X																									X																X						X
SN/358/APN-158A																																																									
4015									X	X																									X																X						X
IP-724/APN-158A																																																									
4016									X	X																									X																X						X
AS-1520/APN-1581																																																									
4017									X	X																									X																X						X
RT-859A/APX-72									X	X		X	X				X															X			X								X	X			X				X		X				X
4019									X	X							X															X			X								X				X				X		X				X
C-6280/APX																																																									
4020									X	X		X	X																						X									X													X
AN/ APM-305A									X	X																									X																X						X
4174									X	X																									X																X						X
RT-804/APN-171									X	X	X														X		X					X														X					X						X
4012									X	X	X																X					X																			X						X
4013																									X		X					X														X											
RT-1057/ARN-103		X		X	X	X			X	X																									X	X	X	X			X										X				X	X	X
4029		X		X	X	X			X	X																									X	X	X	X			X										X				X	X	X
CV-2924/ARN-103																																																									
4028									X	X																									X																						X

MOS 35R20 Avionics Special Equipment Repairer Fault Isolation Tasks / Task #113-610- \ Behavioral Element: Set up, connect, and operate:	Voltmeter/multimeter	Oscilloscope	Signal generator	Wattmeter	Frequency counter	Power supply	Pulse generator	Frequency comparator	Time mark generator	Standing wave indicator	Transfer oscillator	Square law detector	Echo box	Variable attenuator	Variable transformer	Recorder w/preamps	Tape reader	Decade synchro bridge	Radar altimeter test set	Module test set	TACAN test set	Radio test set	Radar test set	Transponder test set	Simulator test set	Pulse power test set	RF power test set	Inertial navigation test set	Gyro stabilized platform t.s.	Test facilities kit	Gyro stabilized platform test stand	Computer mount	Purge and fill unit	Stopwatch	Test tapes	Thermistor mount	Antenna mounting fixture	Carriage	Slotted section	Headset	Probe	Battery
CP-941/ASN-86	X	X			X											X	X	X										X	X		X	X	X	X	X							
0040																	X											X				X			X							
8009																	X											X				X			X							
D-1579/ASN-86																																										
0041	X																X											X							X							
MX-8123/ASN-86																																										
0042	X	X			X											X		X											X		X			X								
8010																																	X									

Figure 2 (cont)

MOS 35R20 Avionics Special Equipment Repairer Fault Isolation Tasks / Behavioral Element	Task #113-610-: P-941/ASN-86	0040	8009	D-1579/ASN-86	0041	X-8123/ASN-86	0042	8010
Measure:								
Voltage	X				X		X	
Resistance	X						X	
Power								
Time	X						X	
Frequency	X						X	
Waveform characteristics	X						X	
Suppression count								
Degrees w/synchro bridge	X						X	
Check continuity	X						X	
Calculate:								
Total loop attenuation								
Cable length								
Stage gain								
Bandwidth								
Average power out								
Difference voltage								
Peak power								
Receiver sensitivity								
Sideband w/cal. curves								
C frequencies								
Power w/cal. curves								
Signal/noise ratio								
Drift rate	X						X	
Monitors test set displays	X	X	X		X			
UUT displays	X				X		X	
Audio on headset								
Signal generator								
Standing wave indicator								
Recorder waveform	X						X	
Identify symptom	X	X			X		X	
Identify faulty component	X	X			X		X	
Interpret charts/tables	X	X			X		X	
Interpret schematics/wiring/test point diagrams							X	
Verify correct performance param.	X	X			X		X	
Adjust: Resistor w/meter								
Resistor w/oscilloscope								
Resistor w/test set display								
Connector body w/meter								
Transformer w/wand & scope								
Capacitor								
Resistor w/UUT display								
Antenna position								
Resolver								
Align synchro								
Load and run tapes	X	X	X		X			
Remove and replace: Covers								
Components	X						X	
Modules								
Lamps								
Cables								
Trays	X	X			X			
Fabricated cable								
Open/close valves	X							X
Perform leak test	X							X

Figure 2 (cont)

MOS 35R20 Avionics Special Equipment Repairer Align/Adjust Tasks — Behavioral Element	Task #113-610- MX-8123/ASN-86	5012
Set up, connect, and operate:		
Voltmeter/multimeter		
Oscilloscope		
Signal generator		
Wattmeter		
Pulse generator		
Sweep frequency generator		
Headset		
Recorder w/preamps	x	x
Frequency counter/meter		
TACAN test set		
Radio test set		
Radar altimeter test set		
Module test set		
Transponder test set		
Radar test set		
Test facilities/maintenance ki		
Dummy load tester		
Simulator test set		
Gyro stabilized platform test set and stand	x	x
Measure:		
Waveform characteristics	x	x
Voltage		
Suppression count		
Power		
Adjust:		
Resistor w/UUT display		
Resistor w/meter	x	x
Resistor w/oscilloscope		
Resistor w/test set display		
Transformer w/oscilloscope		
Tuning screw w/oscilloscope		
Capacitor w/oscilloscope		
Capacitor w/test set display		
Test set control w/oscillo.		
Test set control w/UUT display		
Test set control w/meter		
Remove & replace covers	x	x
Monitor Recorder waveforms	x	x
Assemble/disassemble UUT		
Calculate:		
Total loop attenuation		
Bandwidth		
Center frequency		
Power w/calibration curves		
Drift direction	x	x
Drift in arc minutes	x	x
Drift rate (o/hr)	x	x
Required adjustment	x	x

MOS 35R20 Avionics Special Equipment Repairier Remove and Replace Tasks / Behavioral Elements — Task #113-610-	ASN-86	CP-941/4022	AN/ASN-86 4127	D-1571/4128	MX-3123/4043
Set up, connect, and operate:					
Oscilloscope					
Power supply					
Radio test set					
TACAN test set					
Headset					
Remove and replace:					
Retaining ring					
Fasteners	x	x		x	x
Covers, panels	x	x		x	x
Circuit cards	x	x		x	
Thumbwheels					
Connector pins	x		x		
Gaskets	x				x
Stable element	x				x
Wiring	x		x		
Clamps	x	x			x
Handling fixture	x				x
Support clamp	x				x
Safety block	x				x
Knobs					
Cans					
Ballbearings					
Gears/gear train					
Set screws					
Panel/mount screws					
Nuts/bolts					
Panel lights					
Meters					
Coaxial cables					
Dzus fasteners					
Modules/subassemblies	x				x
Soldered:					
Leads/harness					
Components	x	x		x	x
Semi-conductors					
Monitor test set displays					
Monitor audio signal					
Verify blower operation					
Check continuity	x		x		
Apply: Potting compound					
Sealant	x	x			x
Heat conducting compound					
Lubricant	x				x
Mix lubricant					
Solder/desolder parts					
Torque fasteners	x	x	x	x	x
Clean gasket & mate surface	x				x
Store assembly on foam pad	x				x
Connect/disconnect:					
Electrical connectors	x	x		x	x
Coaxial connectors					
Stripwire w/thermal stripper	x		x		
Adjust: Mechanical alignment	x				x
Resistor w/headset					
Resistor w/test set display					
Interpret mechanical diagrams	x	x	x	x	x

APPENDIX C

INTERVIEWER AND INTERVIEWEE PROTOCOLS

FOR INTERVIEWER:

INTERVIEWEE ______________________________ DATE __________

TITLE ____

ORGANIZATION ______________________________ PHONE __________

INTERVIEWER ____________________

MAJOR AREA OF RESPONSIBILITIES:

	(MOS)	SYSTEM
TRAINING DEVELOPMENT	______	______
MEDIA SELECTION AND DEVELOPMENT	______	______
TRAINING ANALYSIS/EVALUATION	______	______
SQT CONSTRUCTION	______	______
TRAINING	______	______
OTHER ______________	______	______

WHAT IS YOUR OFFICE'S POSITION IN THE SCHOOL SYSTEM RELATIVE TO TRAINING SUPPORT OF A GIVEN SYSTEM?

EXAMPLES OF TASKS YOU DO AND THEIR SEQUENCE:

HOW OFTEN DO YOU DO THOSE TASKS?

DAILY ____________

WEEKLY ____________

MONTHLY ____________

YEARLY ____________

OTHER ____________ ____________

HOW LONG DOES IT TAKE TO DO THEM?

DAY ____________

WEEK ____________

MONTH ____________

YEAR ____________

OTHER ________ ____________

HOW MANY PEOPLE ON YOUR STAFF ARE INVOLVED IN EACH TASK?

WHAT IS YOUR STAFF'S BACKGROUND?

MOS IDENTIFIED FOR JOB ____________

OTHER MOS HOLDER ____________

NON MOS HOLDER ____________

EDUCATION BACKGROUND ____________

WHAT ARE YOUR MOST SIGNIFICANT RESOURCE CONSTRAINTS/PROBLEMS?

TIME ____________

OF PEOPLE ____________

QUALIFICATION OF PEOPLE ____________

MONEY ____________

SYSTEM RELATED ____________

WHAT KIND OF STUDENTS ARE YOU INVOLVED WITH?

1. NEW TRAINEE ____________
2. CROSS TRAINED ____________
3. UPGRADE TRAINEE ____________
4. COMBINATION (#s) ____________

HOW MANY STUDENTS PER YEAR (BY TYPE)?

HOW MUCH OF YOUR TASK IS GOVERNED BY POLICY AND HOW MUCY BY REGULATION (%)? ______________________

WHICH DOCUMENTS DO YOU USE ON YOUR JOB (REGULATIONS, SOPs, MIL SPECS, HANDBOOKS, DATA ITEM DESCRIPTIONS (DIDS), REQUIREMENTS, DOCUMENTS, LETTERS/MEMOS, OTHER?

DO YOU PREPARE ANY OF THE ABOVE DOCUMENTS?

HOW IS THE INFORMATION YOU PRODUCE USED?

WHO RECEIVES IT?

DOCUMENT SAMPLES.

HOW WOULD YOU USE A MATRIX SUCH AS THE GENERALIZED JOB PROFICIENCY MATRIX?

- o SELECTION OF SQT TASKS ____
- o TRAINING SYSTEM DEVELOPMENT ____
- o TRAINING SYSTEM EVALUATION ____
- o TRAINING EQUIPMENT DEVELOPMENT ____
- o TRAINING EQUIPMENT EVALUATION ____
- o TECHNICAL DOCUMENTATION EVALUATION ____
- o MOS MANAGEMENT ____

HOW WILL THE MATRIX CONCEPT'S EMPLOYMENT AFFECT THE DEVELOPMENT TIME OF THE USES YOU HAVE IDENTIFIED:

Shorten____ Lengthen____ No change____

HOW IMPORTANT IS TECHNICAL QUALIFICATION TO THE USE OF THE MATRIX YOU HAVE IDENTIFIED?

No correlation____ Very important____

Depends on use (1 to 10 scale)____

DOES THE USE OF A MATRIX FIT IN WITH THE REGULATIONS GOVERNING YOUR JOB?

Yes____ No____ If no, why:__________________________

HOW SPECIFIC WOULD YOU NEED THE MATRIX CONTENT: EQUIPMENT CLASSIFICATIONS AND BEHAVIOR IDENTIFICATIONS?

Examples:

HOW DO YOU DETERMINE THE SPECIFICITY?

HOW ARE THE TASKS YOU HAVE IDENTIFIED ACCOMPLISHED NOW?

INTERVIEW PROTOCOL

INTERVIEWEE ______________________________ DATE __________

TITLE ____

ORGANIZATION ____________________________ PHONE __________

INTERVIEWER ______________________

MAJOR AREA OF RESPONSIBILITIES

HOW MANY PEOPLE ON YOUR STAFF ARE INVOLVED IN EACH TASK?

WHAT IS YOUR STAFF'S BACKGROUND?

WHAT ARE YOUR MOST SIGNIFICANT RESOURCE CONSTRAINTS/PROBLEMS?

WHAT KIND OF STUDENTS ARE YOU INVOLVED WITH?

HOW MANY STUDENTS PER YEAR (BY TYPE)?

HOW MUCH OF YOUR TASK IS GOVERNED BY POLICY AND HOW MUCH BY REGULATION (%)?

WHICH DOCUMENTS DO YOU USE ON YOUR JOB (REGULATIONS, SOPs, MIL SPECS, HANDBOOKS, DATA ITEM DESCRIPTIONS (DIDS), REQUIREMENTS, DOCUMENTS, LETTERS/MEMOS, OTHER)?

DO YOU PREPARE ANY OF THE ABOVE DOCUMENTS?

HOW IS THE INFORMATION YOU PRODUCE USED?

WHO RECEIVES IT?

HOW WOULD YOU USE A MATRIX SUCH AS THE GENERALIZED JOB PROFICIENCY MATRIX?

HOW WILL THE MATRIX CONCEPT'S EMPLOYMENT AFFECT THE DEVELOPMENT TIME OF THE USES YOU HAVE IDENTIFIED?

HOW IMPORTANT IS TECHNICAL QUALIFICATION TO THE USE OF THE MATRIX YOU HAVE IDENTIFIED?

DOES THE USE OF A MATRIX FIT IN WITH THE REGULATIONS GOVERNING YOUR JOB?

HOW SPECIFIC WOULD YOU NEED THE MATRIX CONTENT: EQUIPMENT CLASSIFICATIONS AND BEHAVIOR IDENTIFICATIONS?

HOW DO YOU DETERMINE THE SPECIFICITY?

HOW ARE THE TASKS YOU HAVE IDENTIFIED ACCOMPLISHED NOW?